Report to the President

IMPLEMENTATION of the RECOMMENDATIONS

of the Presidential Commission on the Space Shuttle Challenger Accident

June 1987

From those who are working to recover
from the *Challenger* loss
to those Americans who will be flying in space
in the near future.

Preface

This final status report describes the actions taken by NASA in response to the recommendations of the Presidential Commission on the Space Shuttle *Challenger* Accident (Mission 51-L). The Commission recommendations and NASA's responses to them are summarized in the Executive Summary, which is accompanied by a schedule showing significant program milestones. Part 1 of the report provides a detailed discussion of the activities undertaken by NASA to implement each of the nine Commission recommendations; Part 2 discusses other related NASA actions required for safe return to flight. A copy of the interim plan submitted to the President one year ago and other significant reference documents are included as appendixes.

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EXECUTIVE SUMMARY

Overview

In the year since the Presidential Commission made its report on the Space Shuttle *Challenger* accident, NASA has prosecuted an intensive, across-the-board effort dedicated to returning to safe, reliable space flight. This recovery activity has three key aspects: the technical engineering changes being selected and implemented; the new procedures, safeguards, and internal communication processes that have been or are being put in place; and the changes in personnel, organizations, and attitudes that have come about.

- The design of the solid rocket motor has been changed. The new design eliminates the weakness that led to the accident and allows incorporation of a number of desirable improvements as well. The new rocket motors will be tested in a series of full-scale firings before the next Shuttle flight.
- Every element of the Shuttle system has been reviewed, and improved hardware and software are being added to enhance safety. For example, the landing system is being improved, the main liquid-fueled engines are being modified to provide additional operating margin, and many other technical improvements to both flight and ground systems are being developed, tested, and incorporated into the overall National Space Transportation System.
- Significant new procedures are being implemented to provide independent safety, reliability, maintainability, and quality assurance functions. A completely new organization, reporting directly to the NASA Administrator, now provides independent oversight of all critical flight safety matters. The new office contributes directly to the solution of technical problems by working with the responsible program organization but retains its separate identity as final arbiter of safety and related matters.
- Sweeping personnel and organizational changes begun immediately after the accident are now complete. A new, streamlined management team has been put in place at NASA Headquarters, with new people well down within the field centers. Special attention is being given to the critical issues of management isolation and the tendency toward technical complacency, which, combined with schedule pressure, led to an erosion in flight safety. It is imperative that return to safe, reliable space flight be accompanied by an intensified awareness that no space flight is without risk, and that NASA's responsibility is to control and contain that risk without claiming its elimination. This philosophy of space flight operations is the controlling one in today's Space Shuttle Program.

This status report on the implementation of the Presidential Commission recommendations records the successful steps taken and those yet to be taken before committing again to send Americans into space. The Presidential Commission investigating the accident issued a formal, in-depth report on June 6, 1986, that grouped its findings and recommendations under nine headings; those same nine headings were used to organize the interim NASA response of June 13, 1986, and are faithfully repeated here, both in this summary and in Part 1 of the full report. Virtually all of NASA's ongoing Shuttle recovery effort is described under the appropriate headings, including work undertaken in addition to the Commission recommendations. For completeness, Part 2 of the report records a number of related NASA activities falling outside the scope of the nine recommendations but integral to the recovery effort.

RECOMMENDATION I

The Commission recommended that the design of the solid rocket motor be changed, that the testing of the new design reflect the operational environment, and that the National Research Council form a committee to provide technical oversight of the redesign effort.

NASA has performed a thorough evaluation of the solid rocket motor design. This effort, although centered on the rocket motor field joint, resulted in design changes to other components of the motor. The field joint has been redesigned to provide high confidence in its ability to seal under all operating conditions. The redesign includes a new tang capture latch that controls movement between the tang and clevis in the joint, a third O-ring seal, insulation design improvements, and an external heater with integral weather seals. The nozzle-to-case joint, the case parts, insulation, and seals have been redesigned to preclude seal leakage observed in prior flights.

The nozzle metal parts, ablative components, and seals have been redesigned to improve redundancy and to provide a capability for pressure verification of seals. Other nozzle modifications include improvements to the inlet, cowl/boot, and aft exit assemblies.

Modifications have been incorporated into the igniter case chamber and into the factory joints to improve their margins of safety. The igniter case chamber wall thickness is being increased. Additional internal insulation and an external weather seal have been added to the factory joint.

Ground support equipment has been redesigned to minimize case distortion during storage and handling, to improve case measurement and rounding techniques for assembly, and to improve leak testing capabilities.

Component laboratory tests, combined with subscale simulation tests and full-scale tests, are being conducted to meet verification requirements. Several small-scale and full-scale joint tests have been successfully completed to date, confirming insulation designs and joint deflection analyses. One engineering test, two developmental, and three qualification full-scale motor test firings will be completed before the next flight. The engineering test motor was fired on May 27, 1987, and early analysis of the data indicates that the test met its objectives.

The horizontal attitude was selected as the optimum position for static firing, and a second test stand, with capability to introduce dynamic loads at the external tank/solid rocket motor aft attach struts, is under construction and will support testing for first flight.

Improved nondestructive evaluation techniques are being developed, in conjunction with the Air Force, to perform ultrasonic inspection and mechanical testing of propellant and insulation bonding surfaces. Complete X-ray testing of all segments will be reinstated for near-term flights.

Contingency planning includes development of alternate designs, which do not utilize existing hardware, for the field and nozzle-to-case joints and for the rocket motor nozzle.

A National Research Council Solid Rocket Motor Independent Oversight Panel, chaired by Dr. H. Guyford Stever, former science advisor to President Nixon, reports directly to the NASA Administrator. The panel is actively reviewing the solid rocket motor design, verification analyses, and test planning and is participating in the major program reviews, including the preliminary requirements and the preliminary design reviews. Three reports containing the panel observations and recommendations have been submitted to the Administrator. The recommendations have been carefully reviewed and appropriate actions have been taken by NASA.

Separate from the oversight panel and working directly with the solid rocket motor design team is a technical advisory group consisting of 12 senior engineers from NASA and the aerospace industry and a separate group of representatives from four major solid motor manufacturers. The advisory group reviews the redesign status and provides suggestions and recommendations to NASA and to Morton Thiokol, the design contractor.

The solid rocket motor manufacturers—Aerojet Strategic Propulsion Company; Atlantic Research Corporation; Hercules Incorporated; and United Technologies Corporation, Chemical Systems Division—were requested under special contracts to review and comment on the present design approach and to propose alternate approaches that they felt would enhance the design. As a result of these and other studies under way, NASA has initiated a definition study for a new advanced solid rocket motor.

RECOMMENDATIONS II AND V

The Commission recommended (II) that the Space Shuttle Program management structure be reviewed, that astronauts be encouraged to make the transition into management positions, and that a flight safety panel be established.

The Commission recommended (V) that the tendency for management isolation be eliminated, that a policy on launch constraints be developed, and that critical launch readiness reviews be recorded.

In March 1986, the newly appointed Associate Administrator for Space Flight, former astronaut Rear Admiral Richard Truly, initiated a review of the Shuttle program management structure and communications. After the Commission report was issued, Captain Robert L. Crippen, a veteran of four Shuttle flights, was assigned responsibility for developing the response to Commission recommendations II and V. This effort resulted in the establishment of a Director, National Space Transportation System (NSTS), reporting directly to the Associate Administrator for Space Flight, and other changes necessary to strengthen the Shuttle program management structure and improve lines of authority and communication.

The Director, NSTS, has two deputies: the Deputy Director, NSTS Program, a NASA Headquarters employee located at the Johnson Space Center (JSC), responsible for day-to-day management and execution of the NSTS program; and the Deputy Director, NSTS Operations, a headquarters employee located at the Kennedy Space Center (KSC), responsible for all operational aspects of the program.

The Director of the Shuttle Projects Office at Marshall Space Flight Center (MSFC) has been designated as a NASA Headquarters employee, reporting to the Deputy Director, NSTS Program, and is responsible for management and technical coordination of the MSFC project elements.

To ensure direct involvement in program activities, the Flight Crew Operations, Mission Operations, and Mission Support directorates at JSC have been designated as NSTS project elements.

At KSC, Shuttle Operations and Engineering have been consolidated under the Director of STS Management and Operations, who is responsible for all Shuttle processing activities and reports to the Center Director. Other KSC organizational realignments have strengthened payload operations and safety, reliability, and quality assurance.

Substantive key personnel changes in the NASA leadership have occurred since the accident. NASA has a new Administrator, Deputy Administrator, and Associate Deputy Administrators for Policy and for Institutions; new associate administrators for Space Flight, for Space Station, for Science and Applications, for External Affairs, and for Safety, Reliability, Maintainability, and Quality Assurance; a new Center Director at KSC and at MSFC; and a new Director and Deputy Director at JSC.

At MSFC, several personnel changes have been made, including the Director of Shuttle Projects, Solid Rocket Booster Project Manager, and Director of Science and Engineering. Additional changes have been made within these organizations to provide strong technical management and leadership.

The Office of Space Flight Management Council has been revitalized. This council, consisting of the Associate Administrator and the directors of JSC, KSC, MSFC, and National Space Technology Laboratories, meets on a regular basis to review program progress, major decisions and issues, and to provide the Associate Administrator with an independent assessment of program status. The Director, NSTS, and his organizational elements support the management council as required.

The flight readiness review and mission management team processes have been strengthened. The Director of Flight Crew Operations will participate in both of these activities and the flight crew commander, or a representative, will attend the flight readiness review. These meetings will be recorded, and formal minutes will be published.

Program management requirements and directives have been updated to ensure that clear, concise direction exists to implement the organizational changes, improve communication among involved program elements, and formalize the overall management of the NSTS Program.

The NSTS funding process has been revised, and the Director, NSTS, now has full control over program funding at the centers.

Since the accident, several current and former astronauts have been assigned to top management positions, including the Associate Administrator for Space Flight; Associate Administrator for External Affairs; Acting Assistant Administrator, Office of Exploration; Chief, Headquarters Operational Safety Branch; Deputy Director, NSTS Operations; JSC Deputy Center Director; Chairman of the Space Flight Safety Panel; and the former Chief of the Astronaut Office as Special Assistant to the JSC Director for Engineering, Operations, and Safety.

A Space Flight Safety Panel, chaired by astronaut Bryan O'Connor, has been established. The panel reports to the Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance. The panel's charter is to promote flight safety for all NASA space flight programs involving flight crews, including Space Shuttle and Space Station.

RECOMMENDATION III

The Commission recommended that the critical items and hazard analyses be reviewed to identify items requiring improvement prior to flight to ensure safety and that the National Research Council verify the adequacy of this effort.

Failure modes and effects analyses, critical item lists, and hazard analyses are techniques used by the NSTS to identify the potential for failure of critical flight hardware; to determine the effect of the failure on the crew, vehicle, or mission; and to ensure that the criticality of the item is reflected in the program documentation.

Several reviews were initiated by program management in March 1986 to reevaluate failure analyses of critical hardware items and hazards. These reviews are providing improved analyses and identifying hardware designs requiring improvement prior to flight to ensure mission success and enhance flight safety.

A review of critical items, failure modes and effects analyses, and hazard analyses for all Space Shuttle systems is well under way. Detailed instructions for preparation of these items were developed to ensure that common ground rules are applied to each project element analysis.

Each NASA element project office and its prime contractor are reviewing their systems to identify any areas in which the design does not meet program requirements; to verify the assigned criticality of items; to identify new items; and to update the documentation. The Astronaut Office and Mission Operations Directorate are participating in these reviews. A parallel review for each element is being conducted by an independent contractor. Upon completion of this effort, each element will submit those items that have failure modes which cannot meet full design objectives to the Program Requirements Control Board, chaired by the Director, NSTS. The board reviews the documentation, concurs in the proposed rationale for safely accepting the item, and issues a waiver to the design requirement, if appropriate.

The National Research Council Committee on Shuttle Criticality Review and Hazard Analysis Audit, chaired by retired USAF General Alton Slay, reports directly to the NASA Administrator. It is responsible for verifying the adequacy of the proposed actions for returning the Space Shuttle to flight status. The committee has visited several Shuttle element prime contractors, JSC, KSC, and MSFC and has hosted a series of technical reviews in Washington, D.C.

In its interim report of January 13, 1987, the committee expressed concern that critical items are not adequately prioritized to highlight items that may be most significant. NASA is implementing a critical items prioritization system for the Shuttle program that is expected to alleviate the committee's concerns.

The committee is continuing its audit by examining the Shuttle risk management approach, including design qualification and flight certification criteria, launch commit criteria and waiver policy, structural margin analyses, software risk management, and the payload safety process. A final committee report is anticipated this year.

RECOMMENDATION IV

The Commission recommended that NASA establish an Office of Safety, Reliability, and Quality Assurance, reporting to the NASA Administrator, with responsibility for related functions in all NASA activities and programs.

The NASA Administrator established a new NASA Headquarters organization, the Office of Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA), and appointed Mr. George Rodney as the Associate Administrator. The Operational Safety Branch of that office is headed by astronaut Fred Gregory. The new organization centralizes agency policy in its areas of responsibility, provides for NASA-wide standards and procedures, and establishes an independent reporting line to top management (up to the NASA Administrator, if required) for critical problem identification and analysis. The new office exercises functional management responsibility and authority over the related organizations at all NASA field centers and major contractors.

The new organization is participating actively and directly in specific NSTS activities such as the hardware redesign, failure modes and effects analysis, critical item identification, hazard analysis, risk assessment, and space flight system assurance. This approach allows the NSTS Program line management at headquarters and in the field to benefit, on a continuing basis, from the professional safety contributions of an independent office without interrupting the two different reporting lines to top management.

Additional safeguards have been added by both the line project management and the SRM&QA organization to ensure that there is free, open, rapid communication upward and downward within all agency activities responsible for safety of flight. Such robust multiple communication pathways should eliminate the possibility of serious issues not rising to the attention of senior management.

RECOMMENDATION VI

The Commission recommended that NASA take action to improve landing system safety margin and to determine the criteria under which planned landings at Kennedy would be acceptable.

NASA is improving the performance, reliability, and safety of the orbiter landing systems and providing additional capability at the various landing sites to reduce risks to crew and equipment during nominal and abort landings.

Several orbiter landing system modifications will be incorporated for the first flight. A tire pressure monitoring system will provide the crew and the Mission Control Center with tire pressure status before deorbit and landing. These data will contribute to the landing runway selection decisions and to overall safe operations. A thick-stator beryllium brake will increase brake energy margin. A change to the flow rates in the brake hydraulic system, a stiffer main gear axle, and a balanced brake pressure application feature will contribute to decreased brake wear upon landing and provide additional safety margin.

Tests at the Langley Research Center test track have defined tire cornering forces and wear characteristics. These data were used in

Ames Research Center simulations to verify landing system performance. Nose wheel steering system gains verified in the Ames simulations are being incorporated into the flight software. A proposed anti-skid system modification was verified by utilizing the flight anti-skid equipment in the Ames simulations.

Several other changes are being evaluated to support longer-term upgrading of the landing system. A new structural carbon brake, with increased energy capacity, has been approved and will be available in 1989. A fail-operational/fail-safe nose wheel steering design, including redundant nose wheel hydraulics capability, is being reviewed by the Orbiter Project Office for later implementation.

The initial Shuttle flights are scheduled to land at the Edwards Air Force Base complex. Total understanding of landing performance data, successful resolution of significant landing system anomalies, and increased confidence in weather prediction capabilities are preconditions to resuming planned end-of-mission landings at the Kennedy Space Center.

RECOMMENDATION VII

The Commission recommended that NASA make every effort to increase the capability for an emergency runway landing following loss of two or three engines during early ascent and to provide a crew escape system for use during controlled gliding flight.

Launch and launch abort mode definition, flight and ground procedures, range safety, weather, flight and ground software, flight rules, and launch commit criteria have been reviewed. Changes resulting from this activity are being incorporated into the appropriate documentation, including ground operating procedures, and the on-board flight data file.

Abort trajectories, vehicle performance, weather requirements, abort site locations, support software, ground and on-board procedures, and abort decision criteria were reviewed to ensure that the requirements provide for maximum crew safety in the event an abort is required. The review resulted in three actions: the landing field at Ben Guerir, Morocco, was selected as an additional transatlantic abort landing site (landing sites available on the European and African continents); ground rules for managing nominal and abort performance were established and the ascent data base was validated and documented; and a permanent Launch Abort Panel was established to coordinate all operational and engineering aspects of ascent-phase contingencies.

The external tank range safety system is being reviewed by representatives from NASA and the Air Force. This review readdresses the issue of whether the range safety system is required to ensure propellant dispersal capability in the event of an abort during the critical first minutes of flight. The results of this analysis will be available in early 1988. Other aspects of the range safety process have been reviewed, and no unresolved issues were identified.

Flight rules (which define the response to specific vehicle anomalies that might occur during flight) are being reviewed and updated. The Flight Rules Document is being reformatted to include both the technical and operational rationale for each rule. The review process is validating the performance limits set for each system and the data source for those limits.

Launch commit criteria (which define responses to specific vehicle and ground support system anomalies that might occur during launch countdown) are being reviewed and updated. These criteria are being modified to include the technical and operational rationale and to document any procedural work-arounds that would allow the countdown to proceed in the event one of the criteria was violated.

Although a final decision to implement a Space Shuttle crew escape capability has not been made, the requirements for a system to provide crew egress during controlled gliding flight have been established. Requirements for safe egress of up to eight crew members were determined through a review of escape routes, time lines, escape scenarios, and proposed orbiter modifications.

The options for crew egress involve manual and powered extraction techniques. Design activities and wind tunnel assessments for each have been initiated. The manual egress design must ensure that the crew member does not contact the vehicle immediately after exiting the crew module. Several approaches being assessed for reducing potential contact include a deployable side hatch tunnel that provides sufficient initial velocity to prevent crew/vehicle contact and an extendable rod and/or rope that places the crew release point in a region of safe exit. Both approaches provide for crew egress through the orbiter side hatch.

The powered extraction technique involves additional weight and crew compartment complexity and must be thoroughly evaluated to ensure that no safety hazards or additional risks would result from its implementation.

Development of a rocket-powered extraction capability for use in a crew egress/escape system has been authorized by the Director, NSTS. Crew escape would be initiated during controlled gliding flight at an altitude of 20,000 feet and a velocity of 200 miles per hour. The system consists of a jettisonable crew hatch (which has been approved for installation and is also applicable to the manual bail-out mode) and individual rockets to extract the crew from the vehicle before it reaches an altitude of 10,000 feet.

Ground egress procedures and support systems are being reviewed to determine their capability to ensure safe emergency evacuation from the orbiter at the pad or following a nonnominal landing. An egress slide, similar to that used on commercial aircraft, is being designed for use should an emergency escape be required after a runway landing.

A study has been initiated to evaluate the feasibility of future escape systems that would potentially expand the crew survival envelope to include first-stage (solid rocket boosters thrusting) flight. Study objectives include determination of system cues to indicate the need for escape, methods of escape initiation, and escape system design.

In support of this overall study, NASA has requested the Naval Air Development Center to lead a team of industry and Government escape system engineers in performing a detailed study of ejection seat concepts to determine the feasibility of using them in the orbiter. The NASA Langley Research Center is performing a similar study for a system to provide rocket extraction from seated positions.

RECOMMENDATION VIII

The Commission recommended that the nation not rely on a single launch vehicle capability for the future and that NASA establish a flight rate that is consistent with its resources.

Several major actions taken over the last year have reduced the overall requirements for NSTS launches and have provided for a mixed fleet of expendable launch vehicles and the Space Shuttle to ensure that the nation does not rely on a single launch vehicle for access to space.

Many of the Department of Defense (DOD) payloads previously scheduled on the NSTS can be launched on expendable launch vehicles. NASA and DOD have worked together to identify these payloads and to replan the overall launch strategy to reflect their launches on expendable launch vehicles.

The presidential decision to limit the use of the NSTS for launch of communication satellites to those with national security or foreign policy implications has resulted in many commercial communication satellites, previously scheduled for launch on the NSTS, being reassigned to commercial expendable launch vehicles. NASA has worked actively with the United States commercial launch vehicle industry and with the satellite owners and operators to ensure that this is an orderly transition.

The Office of Space Flight conducted a study to determine the NASA launch requirements that could be satisfied with a mixed fleet. This study determined that 25 percent of the NASA and the National Oceanic and Atmospheric Administration payloads currently scheduled on the NSTS could potentially be launched on expendable launch vehicles. NASA has developed the overall planning required to implement a mixed fleet, defined the required near- and far-term launch capability, and identified the number and type of launch vehicles necessary to satisfy the requirements.

Each of these major actions will maximize the availability of the Shuttle for missions that require the unique capability provided by the vehicle and its crew.

In March 1986, Admiral Truly directed that a "bottoms-up" Shuttle flight rate capability assessment be conducted. To accomplish this, a flight rate capability working group was established. Representatives from each Shuttle program element that affects flight rate participated in this group.

Ground rules were developed to ensure that projected flight rates are realistic. These ground rules addressed such items as overall staffing of the work force, work shifts, overtime, crew training, and maintenance requirements for the orbiter, main engine, solid rocket motor, and other critical systems.

The group identified enhancements required in the Shuttle mission simulator, Orbiter Processing Facility, the Mission Control Center, and other areas such as training aircraft and provisioning of spares. With these enhancements and the replacement orbiter, NASA projects a maximum flight rate capability of 14 per year with four orbiters. This capacity, considering lead time constraints, "learning curves," and budget limitations, can be achieved no earlier than 1994.

The experience gained during flight rate buildup will be used to adjust future flight rate projections. This will further ensure that flight rates are realistically established and are not driven by other factors.

The manifesting and scheduling of payloads on the Shuttle will be constrained by and totally consistent with realistic flight rate projections as defined above.

Controls have been implemented to ensure that the Shuttle program elements are protected from pressures resulting from late manifest changes. While the manifest projects the payload assignments several years into the future, missions within 18 months of launch are placed under the control of a formal change process controlled by the Director, NSTS. Any manifest change not consistent with the defined capabilities of the Shuttle system will result in the rescheduling of the payload to another mission.

Two independent assessments of Shuttle flight rate capability have been made. The National Research Council published a report in October 1986, which states in part:

> "With a 4-Orbiter fleet, the sustainable flight rate would be 11-13 per year with a surge rate of 15 flights per year only if appropriate ground support facilities are acquired.
>
> "In order to sustain such rates and take account of possible contingencies, the Shuttle scheduling should be based upon the availability of fewer vehicles than are actually in the inventory by almost one Orbiter."

The other independent assessment was made by the Aerospace Safety Advisory Panel. At the conclusion of this study, the panel concurred with the National Research Council report.

RECOMMENDATION IX

The Commission recommended that NASA develop and execute a maintenance inspection plan, perform structural inspections when scheduled, and restore the maintenance and spare parts program.

NASA has updated the overall maintenance and flight readiness philosophy of the NSTS Program to ensure that it is a rigorous and prominent part of the safety-of-flight process.

A System Integrity Assurance Program has been developed that encompasses the overall maintenance strategy, procedures, and test requirements for each element of flight hardware and software to ensure that each item has been properly maintained and tested, and is ready for launch.

Major features of the program ensure design center cognizance and involvement in field center maintenance and operations activities and program management awareness of hardware status, work progress, and technical problems. The NSTS Program Office has the primary responsibility for defining and managing the maintenance safeguards activities; however, the system will provide data to the safety organization to support independent assessments.

The System Integrity Assurance Program Plan establishes requirements for formal verification of vehicle configuration and maintenance activities and defines requirements for system reliability, supportability, and performance monitoring and trend analyses. Program-wide problem reporting and corrective action systems are being implemented for both flight and ground activities.

An information management system to enhance system analysis, verification of requirements, problem reporting, and management insight is being developed. Requirements for this system are being defined with participation from each program element and discipline.

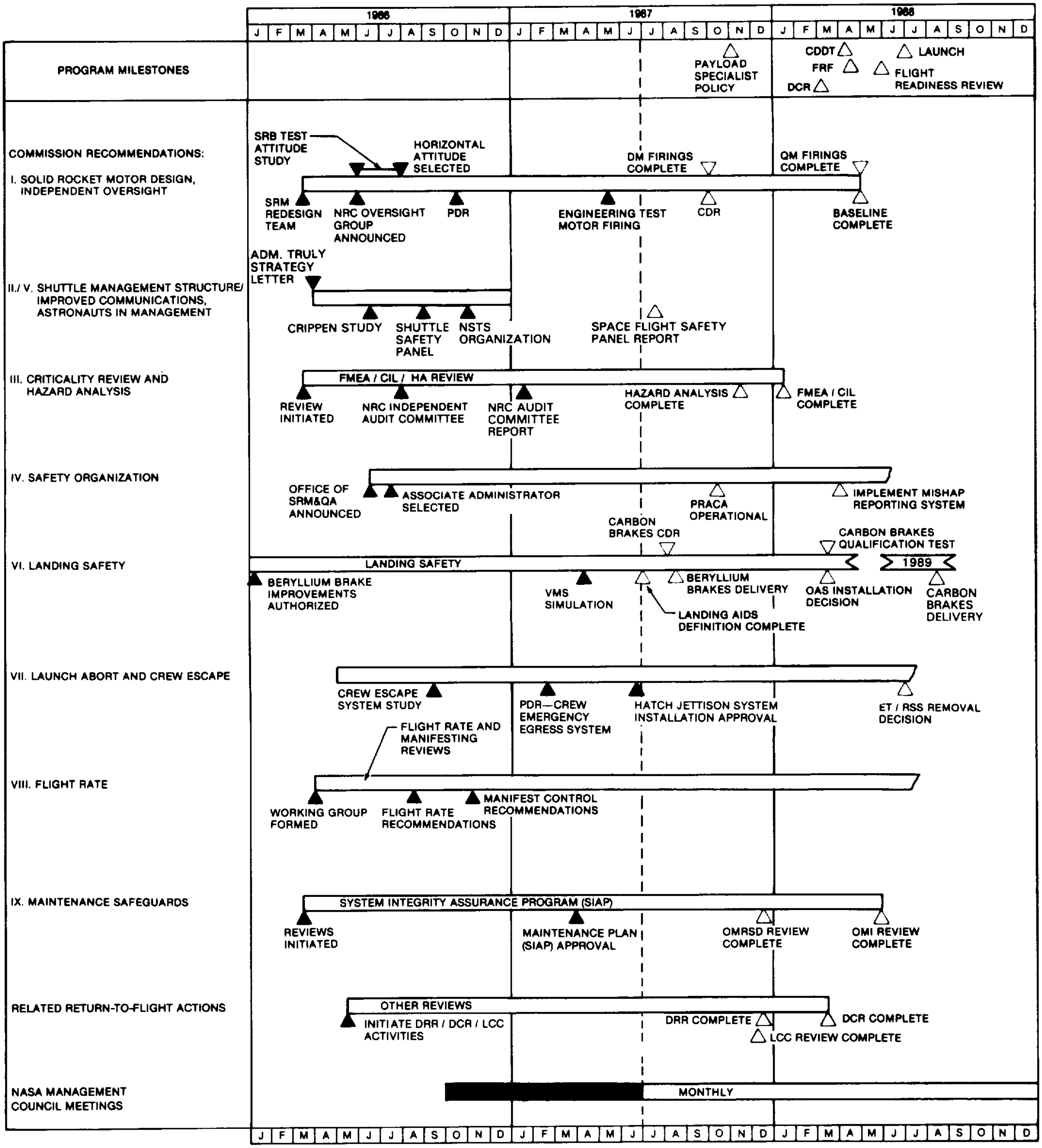
NASA has alleviated the requirement for the routine removal of parts from one vehicle to supply another by expanding and accelerating various aspects of the NSTS logistics program. Procedures are being instituted to ensure that sufficient rationale is available to support any future requirement for such removal of parts and that a decision to remove them undergoes a formal review and approval process.

A vehicle checkout philosophy has been defined which ensures that systems remain within performance limits and that their design redundancy features function properly before each launch. Requirements have been established for identifying critical hardware items in the Operational Maintenance Requirements Specification Document (defines the work to be performed on the vehicle during each turnaround flow) and the Operations and Maintenance Instruction (procedures used in performing the work). These documents are being updated and must have design center concurrence prior to use.

RELATED RETURN-TO-FLIGHT ACTIONS

Several tasks are under way in support of the return-to-flight activities that are not directly related to the Commission recommendations. The Space Shuttle Flight and Ground System Specification and related documents have been updated. System design reviews have been held to identify modifications required to increase margins of safety. A design certification review, wet countdown demonstration test, and flight readiness firing will be conducted prior to flight. Continued astronaut and Mission Control Center training is maintaining flight proficiency as well as training new personnel. A new launch target date and flight crew for the first flight have been identified. These activities are discussed in Part 2 of this report.

Space Shuttle Return to Flight



KEY					
CDDT	Countdown Demonstration Test	FMEA	Failure Modes and Effects Analysis	PDR	Preliminary Design Review
CDR	Critical Design Review	FRF	Flight Readiness Firing	PRACA	Problem Reporting and Corrective Action
CIL	Critical Items List	HA	Hazard Analysis	QM	Qualification Motor
DCR	Design Certification Review	LCC	Launch Commit Criteria	RSS	Range Safety System
DM	Development Motor	NRC	National Research Council	SRB	Solid Rocket Booster
DRR	Design Requirements Review	OAS	Orbiter Arresting System	SRM	Solid Rocket Motor
ET	External Tank	OMI	Operations and Maintenance Instruction	SRM&QA	Safety, Reliability, Maintainability, and Quality Assurance
		OMRSD	Operational Maintenance Requirements Specification Document	VMS	Vertical Motion Simulator

PART 1

IMPLEMENTATION OF THE PRESIDENTIAL COMMISSION RECOMMENDATIONS

Recommendation I

Presidential Commission Recommendation I

Design. The faulty Solid Rocket Motor joint and seal must be changed. This could be a new design eliminating the joint or a redesign of the current joint and seal. No design options should be prematurely precluded because of schedule, cost or reliance on existing hardware. All Solid Rocket Motor joints should satisfy the following requirements:

- The joints should be fully understood, tested and verified.
- The integrity of the structure and of the seals of all joints should be not less than that of the case walls throughout the design envelope.
- The integrity of the joints should be insensitive to:
  - — Dimensional tolerances.
  - — Transportation and handling.
  - — Assembly procedures.
  - — Inspection and test procedures.
  - — Environmental effects.
  - — Internal case operating pressure.
  - — Recovery and reuse effects.
  - — Flight and water impact loads.
- The certification of the new design should include:
  - — Tests which duplicate the actual launch configuration as closely as possible.
  - — Tests over the full range of operating conditions, including temperature.
- Full consideration should be given to conducting static firings of the exact flight configuration in a vertical attitude.

Independent Oversight. The Administrator of NASA should request the National Research Council to form an independent Solid Rocket Motor design oversight committee to implement the Commission's design recommendations and oversee the design effort. This committee should:

- Review and evaluate certification requirements.
- Provide technical oversight of the verification.
- Report to the Administrator of NASA on the adequacy of the design and make appropriate recommendations.

NASA IMPLEMENTATION OF RECOMMENDATION I

SOLID ROCKET MOTOR DESIGN

NASA has reviewed the Commission findings and recommendations and developed a plan to provide a solid rocket motor (SRM) design that satisfies all program design requirements and addresses the Commission recommendations. The primary objective of the redesign effort is to provide a solid rocket motor that is safe to fly. A secondary objective is to minimize the impact on the schedule by using existing hardware if it can be done without compromising safety.

An SRM Redesign Project Plan was developed to formalize the methodology for redesign and requalification of the solid rocket motor, including evaluation and implementation of the recommendations of the Commission. The plan provides an overview of the organizational responsibilities and relationships; the design objectives, criteria, and process; the verification approach and process; and a master schedule. The companion Development and Verification Plan defines the test program and the analyses required for verification of the redesigned and the unchanged components of the SRM. The solid rocket booster configuration is shown in Figure 1.

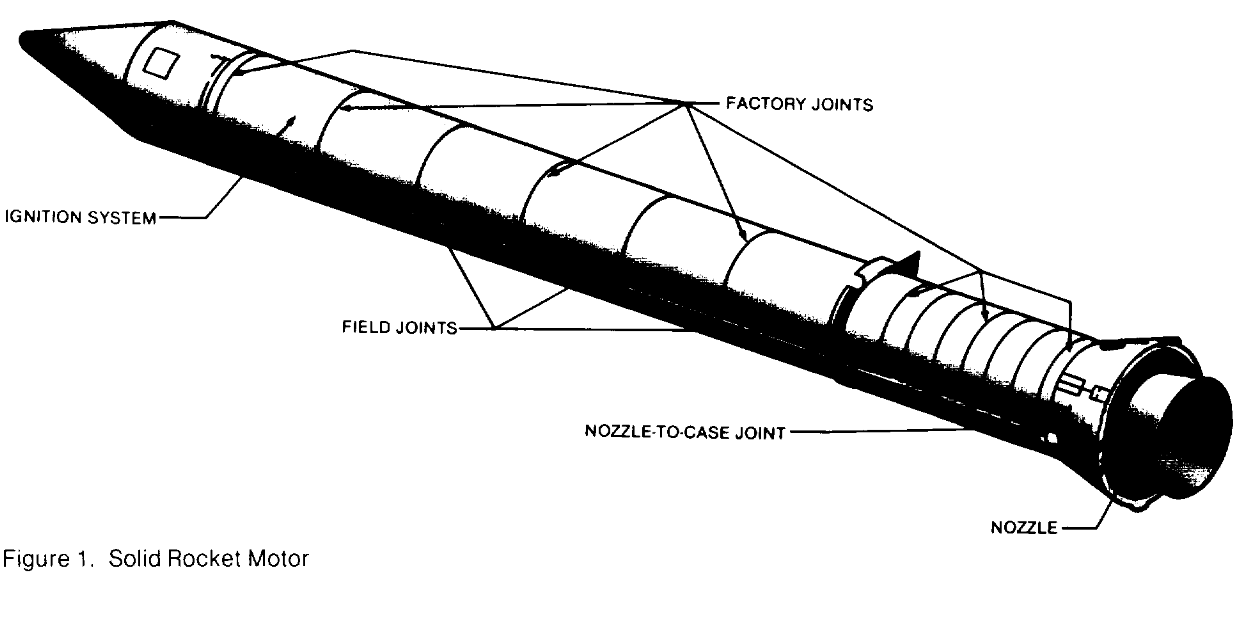


Figure 1. Solid Rocket Motor

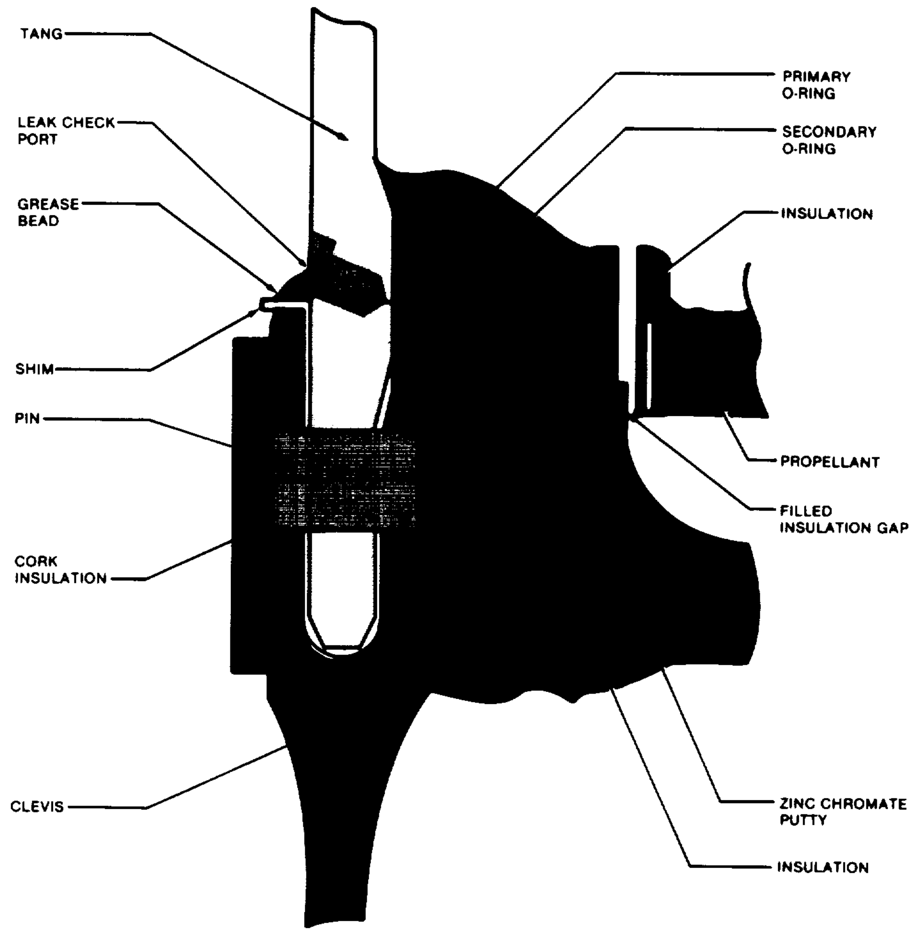


Figure 2. Field Joint (Original Design)

All aspects of the existing solid rocket motor have been assessed, and design changes required in the field joint, nozzle-to-case joint, nozzle, igniter, factory joint insulation, and ground support equipment have been identified. Design criteria have been established for each component to ensure a safe design with an adequate margin of safety. These criteria focus on loads, environments, performance, redundancy, margins of safety, and verification philosophy.

The criteria were converted into specific design requirements during preliminary requirement reviews held in July and August 1986. The design developed from these requirements was assessed at the preliminary design review in September 1986 and baselined in October 1986. The final design will be approved at the critical design review (CDR) to be held in October 1987. Manufacturing of the flight hardware will begin after the CDR and will occur in parallel with the hardware certification process.

The field joint metal parts, insulation, and seals have been redesigned to provide improved structural capability, seal redundancy, and thermal protection. A comparison of the original and new design for the field joint is shown in Figures 2 and 3. A capture latch provides a positive metal-to-metal interference around the circumference of the tang and clevis ends of the mating segments. This interference limits the amount of movement (deflection) between the tang and clevis sealing surfaces due to motor pressure and structural loads. The O-ring seals are designed to not leak under structural deflection of twice the expected values. In the STS 51-L-type design, the application of actuating pressure to the upstream face of the O-ring was essential for proper joint-sealing performance. This was necessary because large sealing gaps were created by pressure-induced deflections, O-ring groove dimensions, the O-ring diameter, and temperature.

The new design, with the tang capture

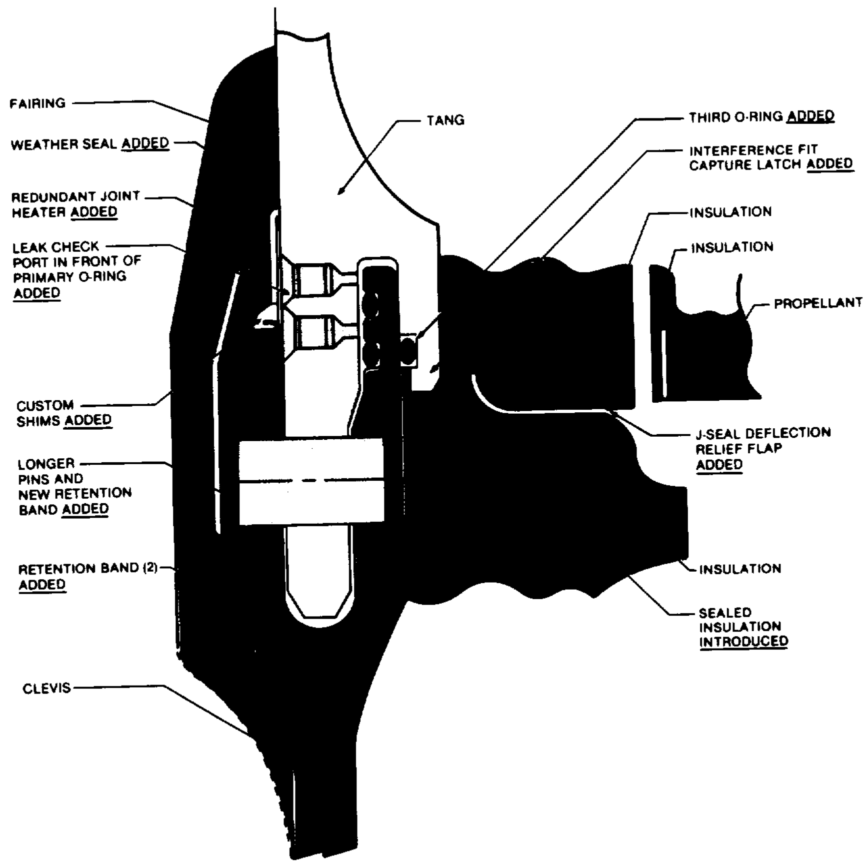


Figure 3. Field Joint (Redesign)

latch and the use of custom-fit shims between the outer surface of the tang and inner surface of the outer clevis leg, controls the sealing gap dimension and ensures positive sealing under operating conditions. The sealing gap and the O-ring seals are being designed so that there is always a positive compression (squeeze) on the O-rings. The minimum and maximum squeeze requirements provide for the effects of temperature, O-ring resiliency and compression set, and pressure. The clevis O-ring groove dimension has been increased so that the O-ring, when fully compressed, never fills more than 90 percent of the groove, and will accommodate, but does not require, pressure actuation.

The new design includes an additional leak check port to verify that there is no leakage after assembly and that the primary and secondary O-rings are positioned in the proper sealing location.

The internal case insulation has been modified to be sealed with a deflection relief flap rather than the putty used in the original configuration. A third O-ring is used to seat the primary O-ring in the proper direction and serve as a thermal barrier should the sealed insulation be breached. Longer case-mating pins, with reconfigured retainer bands, will be used to improve safety margin.

External heaters with integral weather seals will maintain the field joint seal temperatures at or above 75°F and will ensure that a safe seal is maintained within specified operating environments. The weather seal will prevent water from entering the joint.

Analyses and tests identified Viton as the O-ring seal material that best meets the specified requirements to seal under all operating environments with safety margin. The joint seal safety margin will be verified in tests that expose the seal to a combination of ambient temperature limits, storage compression, grease, assembly stresses, and other environments.

The nozzle-to-case joint (Figure 4), which experienced several instances of O-ring damage in flight, has been redesigned to meet the same requirements as the field joint. Sealed radial bolts have been added to minimize joint gap opening, and the insulation has been modified with additional adhesive and an interference fit. Joint closure is enhanced through use of a stress relief flap with a flow baffle and with a wiper O-ring in front of the primary O-ring. The material and size of the primary O-ring have been changed.

The nozzle metal parts, ablative components, and seals have been redesigned. The seals are redundant and verifiable. Improved bonding techniques will be used for nozzle inlet, cowl/boot, and aft exit assemblies. Nozzle inlet assembly distortion is being minimized by increasing the thickness of the aluminum housing and improving fabrication processes. The angle of the carbon cloth phenolic tape wrap (ply), for areas of the throat inlet assembly and the nozzle inlet assembly, has been changed to improve ablative insulation erosion tolerance. The cowl/outer boot ring has additional structural support. These changes will increase the overall margin of safety in the nozzle.

The igniter and the motor case factory joints are being modified. The igniter case chamber, which houses the igniter nozzle insert, is being increased in thickness to improve the margin of safety. The factory joint (Figure 5) is being modified to provide increased margin. Additional internal insulation has been added to the factory joint. The O-ring size and groove and the pin, retainer band, and weather seal of the factory joint

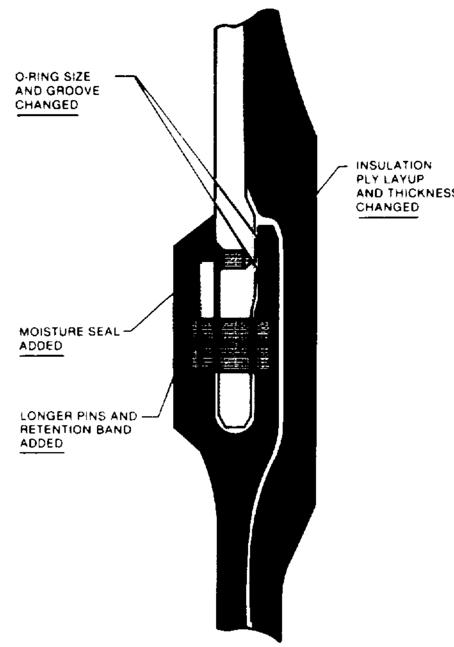


Figure 5. Redesigned Factory Joint

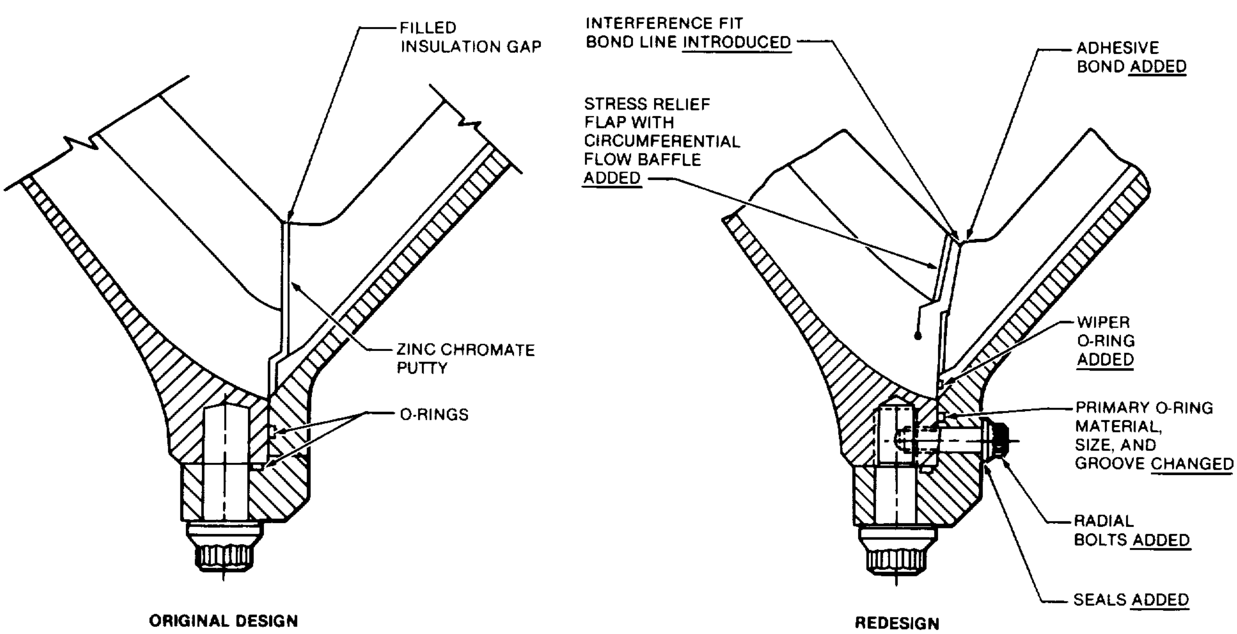


Figure 4. Nozzle-to-Case Joint

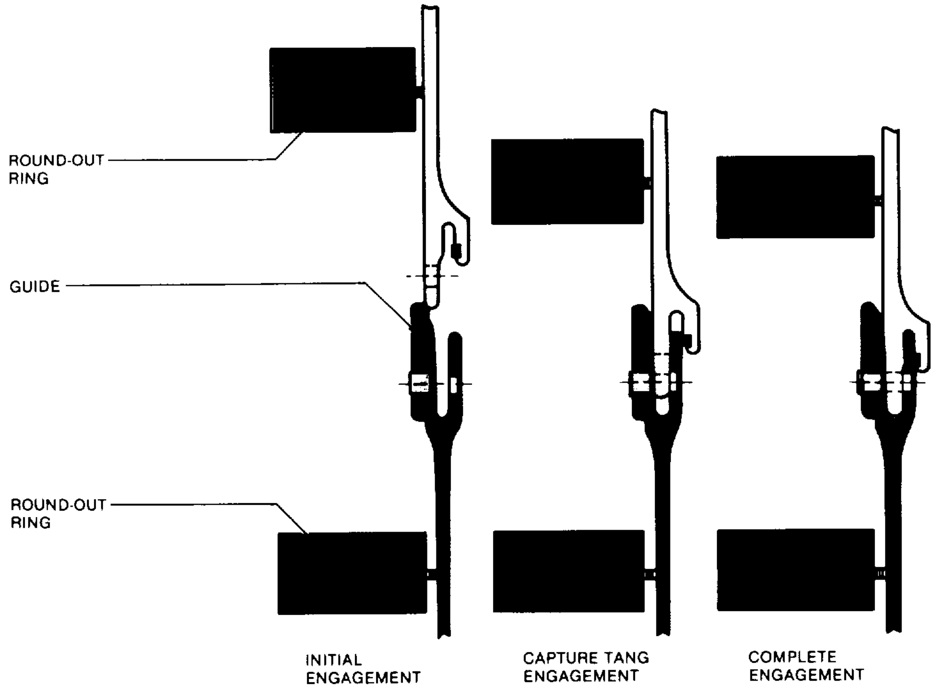


Figure 6. Ground Support Equipment Assembly Aids

have the same, or similar, modifications as those being incorporated into the field joint. Since the factory joints have sufficient insulation and a continuous internal seal, they do not require joint heaters.

The ground support equipment has been redesigned to minimize case distortion during handling and launch site storage; improve the case measurement system; improve methods for case rounding; and improve leak testing capability. These improvements will increase the accuracy of the measurement of case diameters to facilitate stacking, lessen the risk of O-ring damage during assembly, and permit verification of the integrity of the igniter, segment, and nozzle joints after assembly.

Two ground support equipment assembly aids, a guide and round-out rings, shown schematically in Figure 6, will be used in the field joint assembly process. The guide unit clamps to the clevis joint and forces the tang to conform to the same shape as the clevis, while guiding the tang into place. The round-out rings circularize the tang and clevis to assist in joint engagement. Other modifications include changes to the transportation pallet, shaping tools, and the lifting beam. These changes will resolve transportation, handling, and assembly problems that occurred in the past.

Analyses related to structural strengths, loads, stress, dynamics, fracture mechanics, gas and thermal dynamics, and materials characterization and behavior have been conducted to increase the understanding of the joint behavior and to support the design modifications. Continuing analyses will ensure that the design integrity and system compatibility are in agreement with the requirements. These analyses will be verified through correlation of test results and pretest predictions.

The strength of the improved joint design is expected to approach that of the case walls. The selected joint redesign approaches will minimize the sensitivity to manufacturing tolerances, handling, assembly and test procedures, flight operating characteristics, water impact, recovery, and reuse. The solid rocket design process is summarized in Figure 7.

Verification

The SRM Development and Verification Plan describes the test program necessary to demonstrate that the SRM meets all design and performance requirements and that failure modes and hazards have been eliminated or controlled. The verification program includes the development, qualification, acceptance, preflight checkout, flight, and postflight phases.

Final hardware certification will be based, in part, on the results of the subscale tests, development and qualification motor firings, and data analyses. Whereas the development tests are principally engineering-oriented, the qualification tests will be formal demonstrations to verify that flight hardware meets the specified performance and design requirements. The Development and Verification Plan defines a test program that follows a rigorous sequence in which successive tests build on the results of previous tests, leading to formal certification.

Test activities include laboratory and component tests, subscale tests, full-scale simulation, and full-scale motor static firings. Laboratory and component tests are used to determine component properties and characteristics; subscale motor firings are used to simulate gas dynamics and thermal conditions for component and subsystem design.

Ten small-scale motor (70-pound) tests to evaluate both bonded (sealed) and unbonded insulation joint configurations have been completed. The test results were as expected, with no evidence of damage to the primary or secondary O-rings. Four circumferential flow tests have been completed with 400-pound motors, and the results were as predicted.

Fourteen full-scale vertical mate/demate tests have been performed using the joint assembly device as a test article. These tests used the redesigned capture feature hardware and included eight interspersed hydrostatic pressure tests to simulate the flight hardware case growth that results from the initial pressurization cycles. The mate/demate test results were as expected and confirmed the predictions of joint loads.

SRM case growth was identified as a potential problem contributing to improper joint performance during the accident investigation. The growth was suspected to have occurred during hydrostatic proof testing of the motor cases. In order to confirm this, two new cases were selected for measurement before and after several proof-testing cycles. Results confirmed that case growth had occurred during proof-testing cycles but that it became diminishingly smaller after three cycles.

The cause of SRM case growth will be fully understood by NASA prior to the first flight, and any necessary corrective action

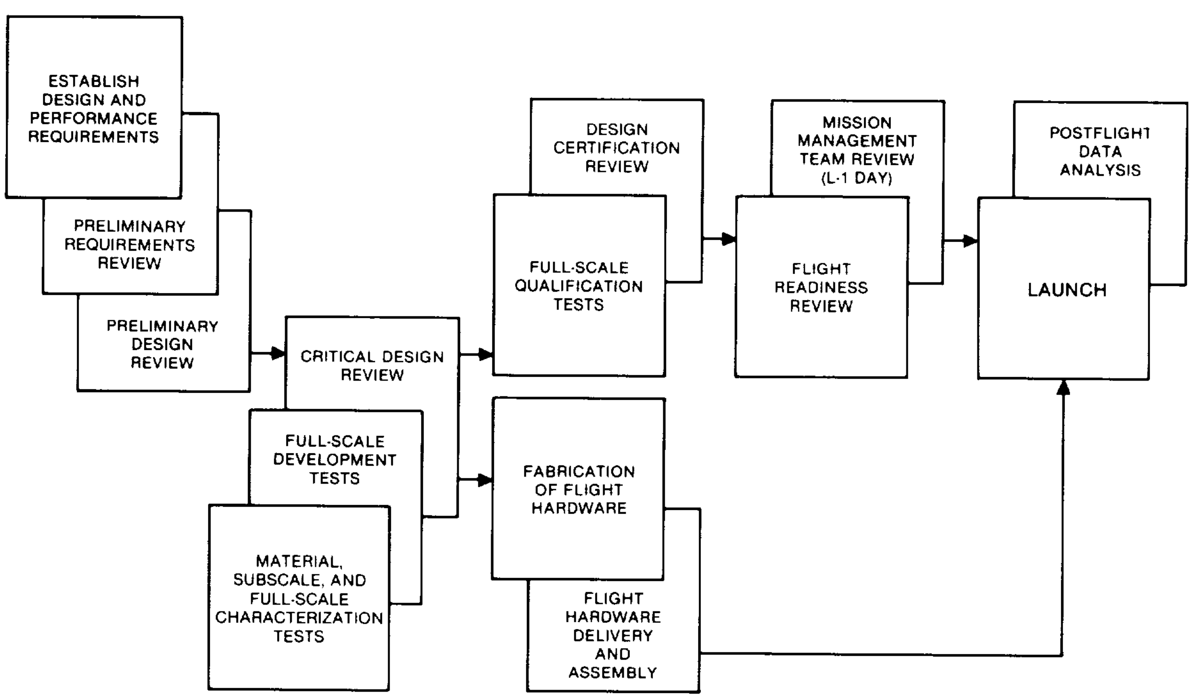
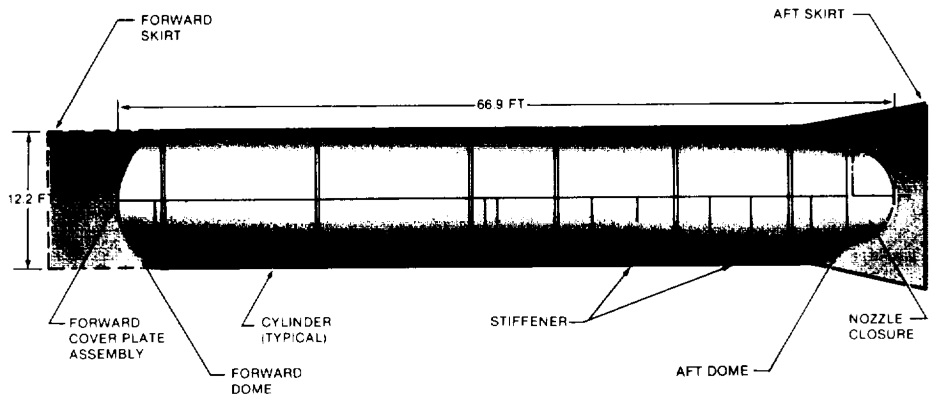


Figure 7. Solid Rocket Motor Design Process



Test Plan

Objectives

- Demonstrate structural integrity of new hardware under prelaunch and flight loads
- Verify structural margins
- Determine joint deflections under loaded conditions

Configuration

- Forward and aft casing segments (empty)
- Forward skirt (nonflight)
- Aft skirt (flight type)
- Nozzle closure for pressurization

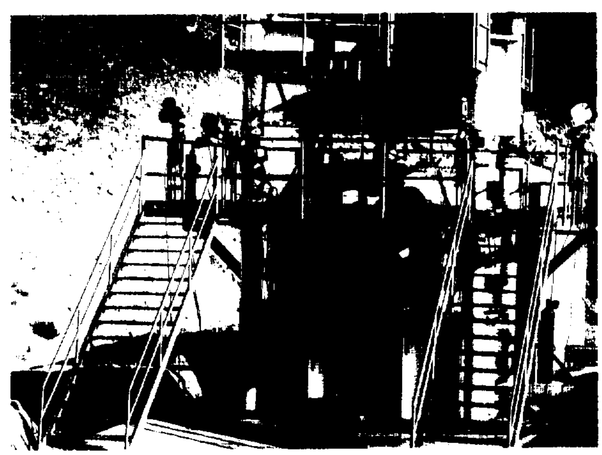
Figure 8. SRM Structural Test Article

will be taken to ensure that both new and refurbished segments will meet all safety and reliability requirements. All case segments will be dimensionally stabilized by multiple proof cycles prior to flight use. Measurements will be made before stacking to confirm that all cases conform to engineering requirements.

The structural test article (STA)—Figure 8—provides the capability to test a flight-type forward segment, aft segment, and aft skirt. Tests utilizing the STA will demonstrate the structural integrity of the redesigned hardware under prelaunch and flight loads and will permit assessment of joint deflections under loaded conditions.

Verification of the new design includes component testing of the actual launch configuration over the full range of operating conditions. Full-scale, short-duration component tests of the field and nozzle joints that include joint flaws and flight loads will be used to verify analytical models and to determine hardware assembly characteristics, deflection characteristics, and overall performance. The results of these tests and analyses will be used to determine redesigned hardware structural characteristics.

Test programs that utilize full-scale flight design hardware include the nozzle joint environment simulator, the joint environment simulator (JES), and the transient pressure test article. These tests subject the SRM design features to the maximum expected operating pressure, maximum pressure rise rate, and temperature extremes during ignition tests. The transient pressure test article will be subjected to prelaunch loads during firing. Figures 9 and 10 depict test configura-



Test Plan

Objectives

- Measure nozzle/case joint deflection, temperatures, and pressures
- Determine seal performance at low/high temperature
- Monitor nozzle/case joint insulation performance

Configuration

- Nozzle-to-case joint
- Full-scale aft dome
- Full-scale forward dome with igniter
- Pressurized with hot gas

Performance

- Burn time = 0.5 sec
- Pressure decay time = 80 sec

Figure 9. SRM Nozzle Joint Environment Simulator

ORIGINAL PAGE
COLOR PHOTOGRAPH

Test Plan

Objectives
- Measure joint deflection, temperatures, and pressures
- Determine seal performance at low/high temperature
- Monitor case joint insulation performance

Configuration
- Full-scale case components loaded with inert propellant
- Pressurized with hot gas

Performance
- Burn time = 0.6 sec
- Pressure decay time = 90 sec

Figure 10. SRM Joint Environment Simulator

tions and describe the objectives for two of these full-scale hardware simulators. Figure 11 is a sketch of the complete transient pressure test article facility.

Three nozzle joint simulator tests have been successfully conducted. The STS 51-L configuration test confirmed predicted nozzle-to-case joint deflection. The other two tests using the new configurations with the radial bolts confirmed predictions of nozzle closure at maximum motor pressure.

Four joint environment simulator tests have been conducted. The JES-1 test series of two tests used the STS 51-L hardware configuration with and without a prefabricated defect in the putty and with joint temperatures of 20°F. These tests established a structural and performance data base for the STS 51-L configuration.

The JES-2 tests were conducted using STS 51-L motor case hardware with the new bonded seal insulation-application technique. Tests were conducted with and without flaws built into the seals in the joints, and neither test showed any evidence of O-ring erosion or blow-by.

Full-scale motor static firings will be conducted to confirm the integrated SRM performance. Six full-scale motor, full-duration static firings are planned. These firings include the engineering test motor (Figure 12), which was successfully fired on May 27, 1987, and will provide a data base for the 51-L-type field, case-to-nozzle, and factory joints. The engineering test motor evaluated changes in the nozzle and the effectiveness of graphite composite stiffener rings to reduce joint deflections. Early analysis of the data indicates that the test met its objectives.

Two development motor firing tests (DM8 and DM9) and three qualification motor firing tests (QM6, QM7, and QM8) are planned for completion prior to the first flight. At least three successful qualification motor firings are required for final configuration and performance certification. Two of the qualification motors (QM7 and QM8) will be subjected to flight dynamic loads and a predetermined thermal environment during firings.

The static firing test attitude required to completely verify the design changes was assessed. The assessment included the establishment of test objectives, definition and quantification of the attitude-sensitive parameters, and evaluation of the attitude options. The horizontal and vertical (nozzle up and down) test attitudes were assessed.

In all options, consideration was given to testing with and without externally applied loads. The horizontal attitude was determined to represent a more demanding test configuration for the conditions influencing the joint and insulation behavior and has been retained.

A second horizontal test stand is being constructed and will support testing for first flight. The new stand, designated as the T-97 Large Motor Static Test Facility (Figure 13), will simulate environmental stresses, loads, and temperatures experienced during an actual Space Shuttle launch and ascent.

Nondestructive Evaluation (NDE)

NASA and several contractors are addressing both near-term and far-term nondestructive inspection testing at various stages of the SRM manufacturing process. X-ray of the propellant for all segments is being reinstated for the near-term flights. This X-

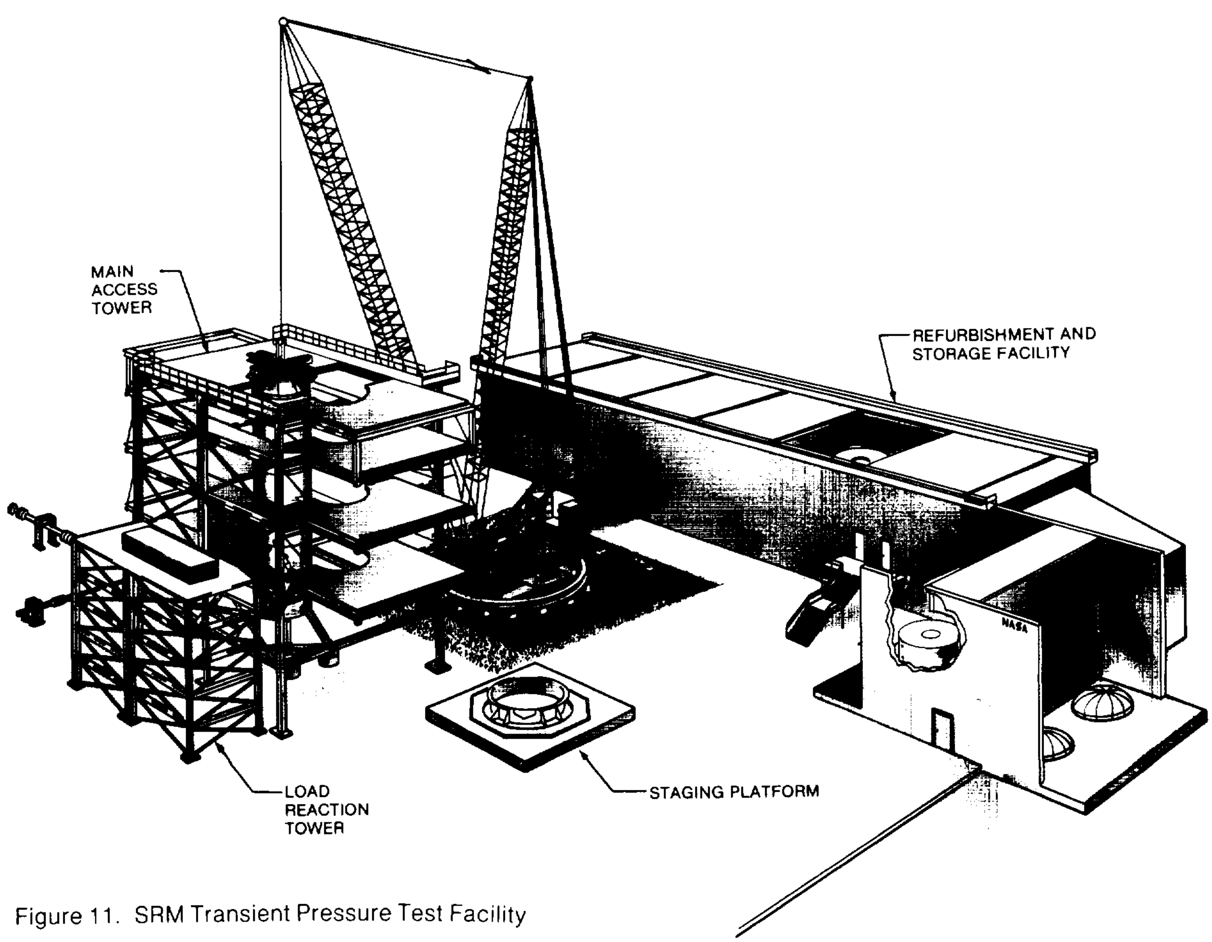


Figure 11. SRM Transient Pressure Test Facility

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Test Plan

Objectives

- Provide a data base for 51-L field joints
- Evaluate new seal material
- Evaluate addition of graphite stiffener rings
- Evaluate new ply angle in motor nozzle
- Evaluate new ET attach ring structure
- Evaluate addition of field joint heaters

Configuration

- Full-scale motor containing 51-L joint configurations and the above modifications

Figure 12. SRM Engineering Test Motor

ray effort will be performed at the manufacturing facility. For the long term, continuation of full X-ray inspection versus a sampling approach will be assessed. This assessment will be based upon technology advancements, other inspections performed, and the accumulated experience base.

NASA has consulted with the Department of Defense in detail on the nondestructive testing plans of the Titan recovery program. The Associate Administrator for SRM&QA formed an agency-level group on nondestructive testing of the SRM that is addressing both near- and far-term methodology. This group, chaired by Dr. Joe Heyman of the Langley Research Center, draws upon the expertise of several appropriate contractors. The full spectrum of possible techniques is being assessed, including infrared thermography, various ultrasonic methods, and computer tomography.

Contingency Planning

To provide additional program confidence, both near- and long-term contingency planning has been implemented. Alternate designs, which might be incorporated into the flight program at discrete decision points, include field joint graphite composite overwrap bands and alternate seals for the field joint and nozzle-to-case joint. Alternate designs for the nozzle include a different composite layup technique and a steel nose inlet housing.

Alternate designs with long lead time implications are also being developed. These designs focus on the field joint and nozzle-to-case joint. Since fabrication of the large steel components dictates the schedule, long lead procurement of maximum-size steel ingots has been initiated. This will allow machining of case joints to either the new baseline or to an alternate design configuration. Ingot processing will continue through forging and heat treating. At that time, the final design will be selected. A principal consideration in this configuration decision is the result of verification testing on the baseline configuration.

INDEPENDENT OVERSIGHT

The National Research Council (NRC) established an Independent Oversight Panel to review the SRM redesign. This panel, chaired by Dr. H. Guyford Stever, reports directly to the NASA Administrator. The panel was briefed on the Shuttle system requirements, the original design and manufacturing of the SRM, the mission 51-L accident analyses, and preliminary plans for the redesign.

Panel members have met with SRM manufacturers and vendors and have visited some of their facilities. They have reviewed the SRM design criteria, engineering analyses and design, certification program planning, verification testing, material specification selection, and quality assurance and control. They will continue to review the design as it progresses through manufactur-

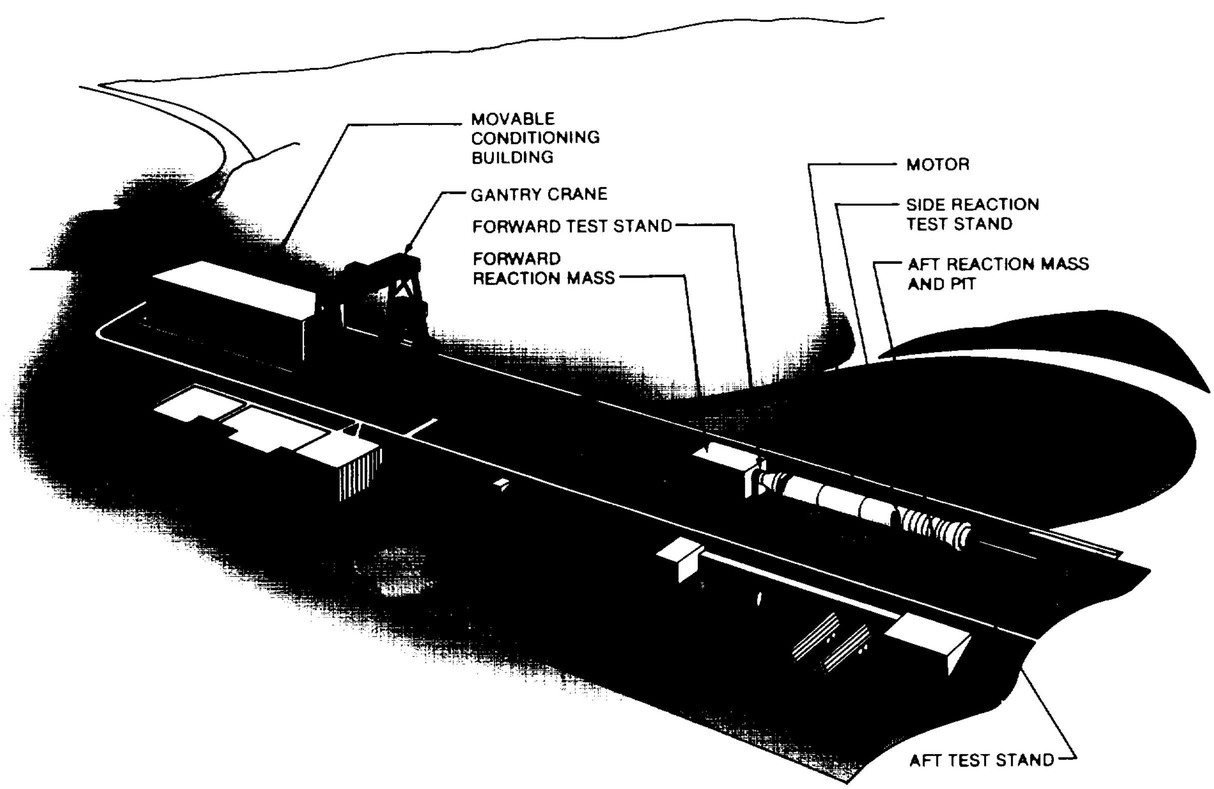


Figure 13. T-97 Large Motor Static Firing Test Facility

ing, assembly of the first flight SRM, and design certification. Panel members participated in the preliminary requirements review and the preliminary design review, and will participate in future reviews.

The panel has held a number of full meetings and numerous subpanel and individual member meetings, and has submitted three written status reports to the NASA Administrator. Although NASA has not yet formally responded to these status reports, actions have been taken to implement most of the committee recommendations. NASA has held several meetings with the committee to discuss and review the status of the response to the recommendations. The NRC membership and a summary of the panel responsibilities are provided in Appendix A.

In addition to the NRC panel, an advisory group of 12 experienced senior engineers from NASA and the aerospace industry are supporting the redesign team. They review the design activities and provide recommendations for major program decisions. The membership and a summary of the group's responsibilities are provided in Appendix B.

NASA requested four other major solid rocket motor companies—Aerojet Strategic Propulsion Company, Atlantic Research Corporation, Hercules Incorporated, and United Technologies Corporation's Chemical Systems Division—to participate in the redesign efforts. Each company was given a short study contract and requested to critique the present redesign approach and to submit concepts for alternate designs. Their critiques were used in finalizing the design criteria and ensuring that industry standards are implemented into the final design selection. Hercules, Atlantic Research, and United Technologies are continuing to support the redesign by conducting special design and test activities.

As a result of the studies by these companies and others by NASA, a study to define a new advanced solid rocket motor has been initiated.

Further changes to the SRB are discussed in Part 2 of this report.

Recommendations II and V

Presidential Commission Recommendation II

Shuttle Management Structure. The Shuttle Program Structure should be reviewed. The project managers for the various elements of the Shuttle program felt more accountable to their center management than to the Shuttle program organization. Shuttle element funding, work package definition, and vital program information frequently bypass the National STS (Shuttle) Program Manager.

A redefinition of the Program Manager's responsibility is essential. This redefinition should give the Program Manager the requisite authority for all ongoing STS operations. Program funding and all Shuttle Program work at the centers should be placed clearly under the Program Manager's authority.

Astronauts in Management. The Commission observes that there appears to be a departure from the philosophy of the 1960's and 1970's relating to the use of astronauts in management positions. These individuals brought to their positions flight experience and a keen appreciation of operations and flight safety.

- NASA should encourage the transition of qualified astronauts into agency management positions.
- The function of the Flight Crew Operations director should be elevated in the NASA organization structure.

Shuttle Safety Panel. NASA should establish an STS Safety Advisory Panel reporting to the STS Program Manager. The charter of this panel should include Shuttle operational issues, launch commit criteria, flight rules, flight readiness, and risk management. The panel should include representation from the safety organization, mission operations, and the astronaut office.

Presidential Commission Recommendation V

Improved Communications. The Commission found that Marshall Space Flight Center project managers, because of a tendency at Marshall to management isolation, failed to provide full and timely information bearing on the safety of flight 51-L to other vital elements of Shuttle Program management.

- NASA should take energetic steps to eliminate this tendency at Marshall Space Flight Center, whether by changes of personnel, organization, indoctrination or all three.
- A policy should be developed which governs the imposition and removal of Shuttle launch constraints.
- Flight Readiness Reviews and Mission Management Team meetings should be recorded.
- The flight crew commander, or a designated representative, should attend the Flight Readiness Review, participate in acceptance of the vehicle for flight, and certify that the crew is properly prepared for flight.

NASA IMPLEMENTATION OF RECOMMENDATIONS II AND V

Because of the integral relationship between management structure and communications, the response to these two Commission recommendations is combined in this section of the report. The changes in management structure and improved communications will permit early detection and timely resolution of potential problems. Regular management reviews will provide frequent, in-depth assessments of program status and issues. This top-level review concept is structured for flexibility in responding to problems and meeting contingencies as they arise.

SHUTTLE MANAGEMENT STRUCTURE

The National Space Transportation System (NSTS) Program management structure has been reviewed, and major changes in the organization, personnel, and management philosophy have been implemented. The program reporting channels have been redefined and streamlined.

In March 1986, Rear Admiral Richard Truly, Associate Administrator for Space Flight, initiated a NASA Headquarters review of the Space Shuttle Program management structure and other major activities necessary for the program to resume the flight schedule (Appendix C). In May 1986, the NASA Administrator requested retired USAF Lt. General Samuel C. Phillips, formerly the Apollo Program Director, to review the overall NASA management structure and to recommend changes necessary to improve the management of its programs and people. General Phillips' management study group undertook an 8-month comprehensive assessment of NASA's management practices and performed a thorough evaluation of the overall effectiveness. This study was completed in December 1986. Major recommendations were to establish centralized headquarters responsibility for all programs and to restructure the agency to improve the lines of communication.

In June 1986, after receipt of the Commission report, astronaut Captain Robert L. Crippen was assigned the responsibility for developing the response to Commission recommendations II and V. The objective of the Crippen effort was to identify and propose those changes necessary to strengthen the management of the program. The results of this effort, completed in August 1986, were consistent with the subsequent Phillips committee recommendation that the position of Director, NSTS, be established at NASA Headquarters. This and the other recommendations of the study were implemented by a November 5, 1986, letter of direction from the Associate Administrator for Space Flight (Appendix D). Figures 14 and 15 portray the pre-STS 51-L Office of Space Flight organizational structure and the revised structure, respectively.

The Director, NSTS, reports directly to the Associate Administrator for Space Flight and has overall responsibility for the NSTS Program. The Director, NSTS, is supported by two deputies and the program/project organizational elements.

The Deputy Director, NSTS Program, a headquarters employee located at the Johnson Space Center (JSC), is responsible for the day-to-day management and execution of the program. He is specifically responsible for establishing, implementing, and controlling program requirements; providing program planning, direction, scheduling, and maintenance for NSTS configuration management and control; providing system engineering and integration of the flight vehicle, ground systems, and facilities; integrating the specific mission requirements with the orbiter vehicle for each flight; and performing mission planning and integration.

The pre-STS 51-L organization for the NSTS Program Office is shown in Figure 16, and the current organizational structure is shown in Figure 17. In the new organization, the project offices support the Deputy Director, NSTS Program, and report programmatically through him to the Director, NSTS. The integration and operations, engineering integration, management integration, safety, reliability, and quality assurance (SR&QA),

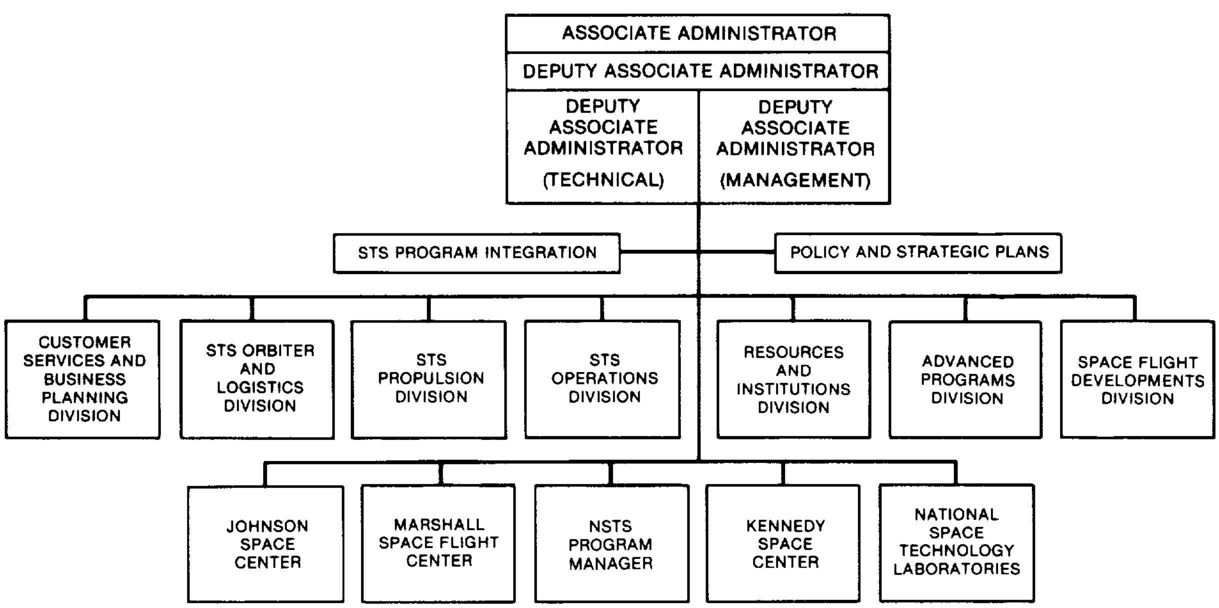


Figure 14. Office of Space Flight (Pre-STS 51-L Organization)

and program control elements report directly to the Deputy Director, NSTS Program. The Manager for SR&QA is provided from the JSC Directorate of SR&QA.

The Deputy Director, NSTS Operations, a headquarters employee located at the Kennedy Space Center (KSC), is responsible for all operational aspects of the NSTS missions and is specifically responsible for final vehicle preparation, mission execution, and return of the orbiter for processing for its next flight; management of the scheduling and presentation of flight readiness reviews; management of the final launch decision process, including final authority for launch commitment; and chairing the mission management team. This team, composed of senior program management officials, is responsible for reviewing all major launch and in-flight issues and for making those decisions that affect mission objectives.

The operations integration offices at JSC, KSC, and Marshall Space Flight Center (MSFC) report directly to the Deputy Director, NSTS Operations, and are responsible for assessing flight plans, mission rules, launch commit criteria, training and mission preparation, launch site readiness, flight anomaly closeout, and other operational activities at their respective centers.

The Manager of Shuttle Projects at MSFC, also a headquarters employee, is responsible for overall management and coordination of the MSFC elements (solid rocket boosters, external tank, and Space Shuttle main engines). These project elements report through him to the Deputy Director, NSTS Program. This organizational alignment permits direct interaction between the Deputy Director, NSTS Program, and the MSFC element project managers.

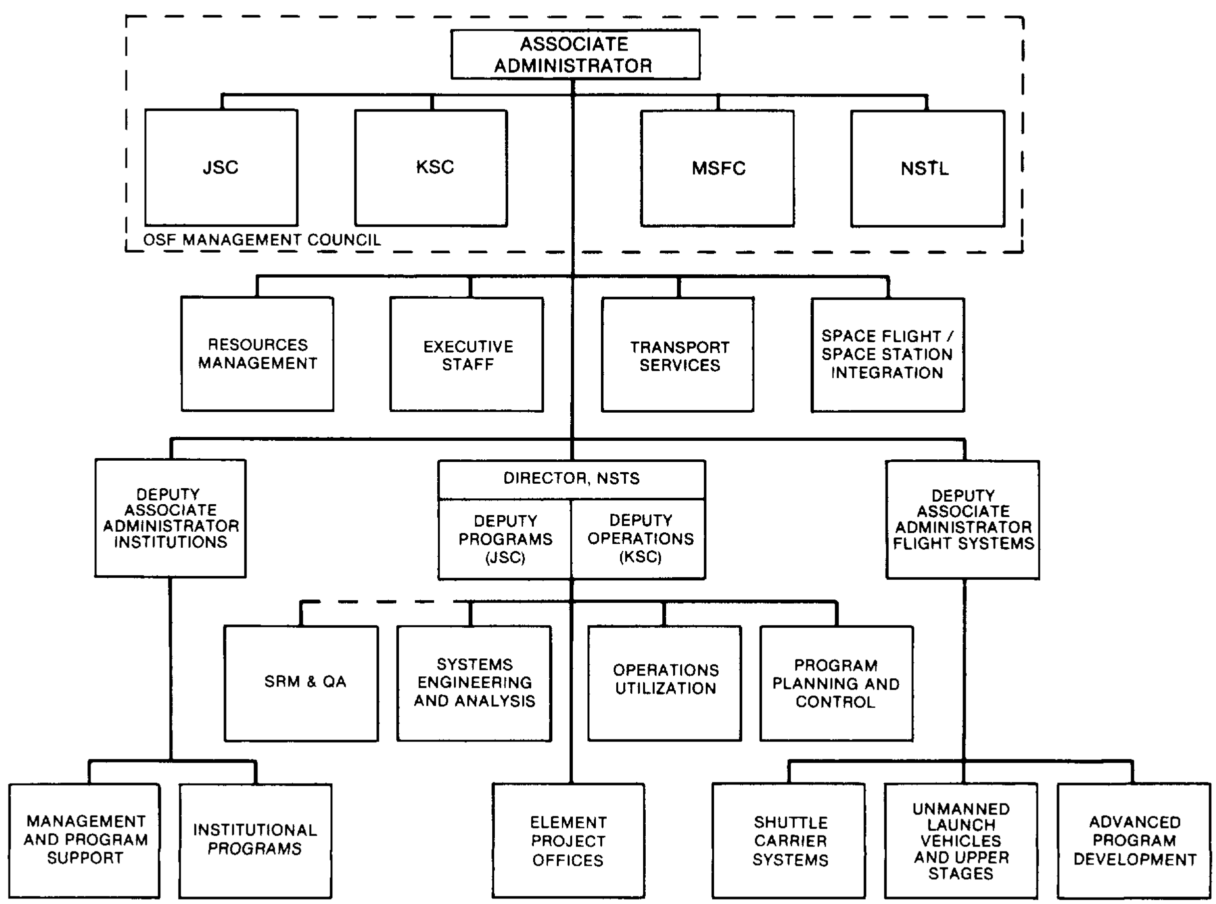


Figure 15. Office of Space Flight (Current Organization)

To ensure direct involvement in program activities, the Flight Crew Operations, Mission Operations, and Mission Support offices at JSC have been designated as project elements, reporting programmatically to the Deputy Director, NSTS Program. Institutionally, these organizations now report directly to the JSC Director.

Shuttle operations and engineering at KSC have been consolidated, as a project element, under a new Director of STS Management and Operations, who reports institutionally to the Center Director. Other institutional realignments have strengthened overall Shuttle operations, including SR&QA, and have made center organizations compatible with the NSTS management structure.

The Director, NSTS, now has full responsibility for the NSTS Program budget and for balancing program content across all elements. The NSTS funding process has been revised. Requirements are identified and reviewed by each center director, and the approved center request is submitted to the program. The Deputy Directors, NSTS, review the submittals and forward combined assessments and recommendations, including any balancing of requirements across the projects or centers, to the Director, NSTS. These recommendations are reviewed and a proposed budget is submitted to the Associate Administrator for integration into the Office of Space Flight budget request. This revised process was used in the recent budget cycle and worked satisfactorily. The Director, NSTS, has full responsibility for the implementation of the approved NSTS budget.

The NSTS project offices are institutional organizations; however, they report programmatically through the Deputy Director, NSTS Program, to the Director, NSTS.

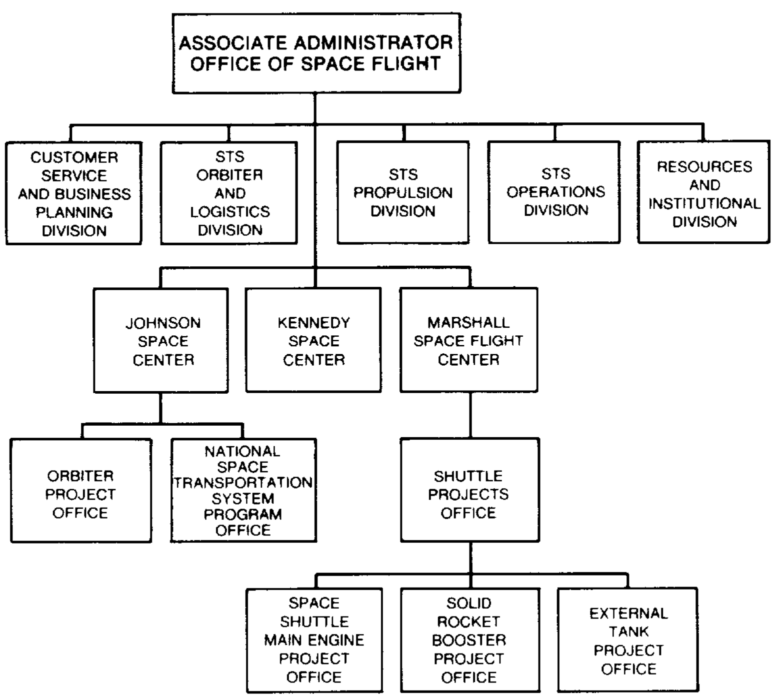


Figure 16. NSTS Program Management Organization (Pre-STS 51-L)

The respective center directors are responsible and accountable for the technical excellence and performance of the project elements assigned to their centers and for providing the institutional support required to manage the NSTS Program.

The Office of Space Flight Management Council has been revitalized. This council, consisting of the Associate Administrator and the directors of JSC, KSC, MSFC, and National Space Technology Laboratories, meets on a regular basis to review program progress, major decisions, and issues, and to provide the Associate Administrator with an independent assessment of program status. The Director, NSTS, and his organizational elements support the management council as required.

Many personnel changes have occurred within the NASA organization since the accident. NASA has a new Administrator; Deputy Administrator; Associate Deputy Administrators for Policy and for Institutions; new Associate Administrators for Space Flight, for Space Station, for Science and Applications, for External Affairs, and for Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA); new Center Directors for KSC and MSFC; and a new Center Director and Deputy Director at JSC. At MSFC, other personnel changes include the Manager of Shuttle Projects, the Solid Rocket Booster Project Manager, the Director of Science and Engineering, and several key positions within their organizations.

ASTRONAUTS IN MANAGEMENT

NASA is continuing its policy of assigning astronauts to management positions to benefit from their management ability and

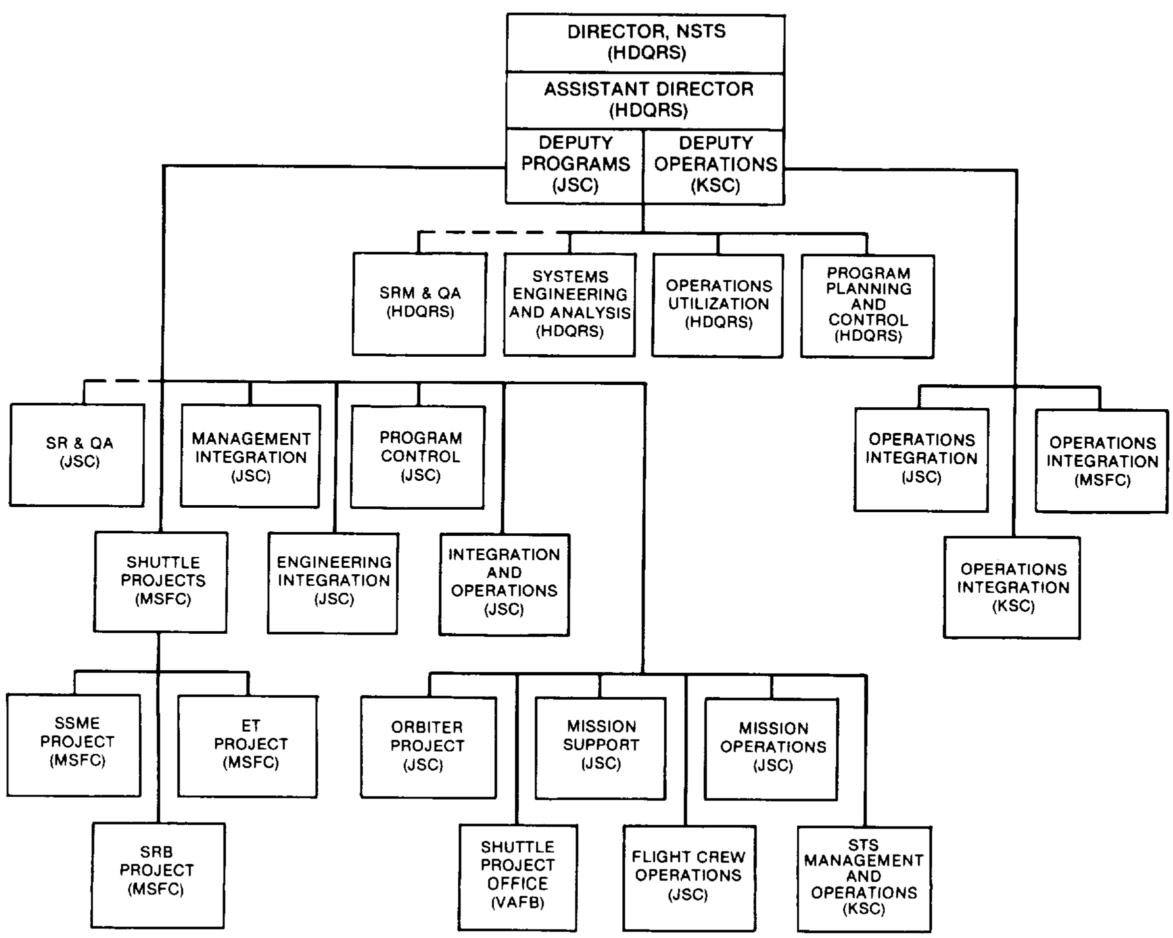


Figure 17. NSTS Program Management Organization (Current)

specific space flight experience. At the present time, ten current or former astronauts hold key agency management positions. The specific personnel and positions are listed in Table 1. NASA will continue to encourage astronauts to participate in the management process, both on a permanent and a rotational basis. This policy is beneficial from two aspects: (1) the agency and program acquire very capable management personnel with significant operational experience, and (2) astronauts who rotate through management positions and return to flight status carry with them a better understanding of the program process.

SPACE FLIGHT SAFETY PANEL

NASA has established a Space Flight Safety Panel, chaired by astronaut Bryan O'Connor. To maximize the panel's independence, it reports to the Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance. The panel's charter is to promote a NASA space flight safety program for space programs involving flight crews and to advise and assist the appropriate associate administrators in the administration and monitoring of flight safety aspects of their programs. The panel's purpose is to preserve human and material resources and to enhance space flight operations whenever flight safety is affected. The panel roles and responsibilities are defined in NASA Management Instruction 1152.66 (Appendix E).

The Space Flight Safety Panel is composed of an astronaut with space flight experience, a JSC flight director, an MSFC mission manager, and a KSC test director. The Commission recommended that the panel

Table 1. Astronauts in Management

Astronaut	Position	Location
Rear Admiral Richard Truly	Associate Administrator for Space Flight	NASA Headquarters
Dr. Sally Ride	Acting Assistant Administrator, Office of Exploration	NASA Headquarters
Captain Rick Hauck	Associate Administrator for External Affairs (August 1986-January 1987)	NASA Headquarters
Colonel Fred Gregory	Chief, Operational Safety Branch Office	NASA Headquarters
Captain Robert Crippen	Deputy Director, NSTS Operations	Kennedy Space Center
Paul Weitz	Deputy Director	Johnson Space Center
John Young	Special Assistant to the Director for Engineering, Operations, and Safety	Johnson Space Center
Lt. Colonel James Adamson	Assistant Manager for Engineering Integration, NSTS Program Office	Johnson Space Center
Colonel Charles Bolden	Chief, Safety Division	Johnson Space Center
Colonel Brewster Shaw	Chairman, Orbiter Modification Team	Johnson Space Center
Colonel Bryan O'Connor	Assistant Manager for Operations, NSTS Program Office, Chm., Flight Safety Panel	Johnson Space Center

membership include a representative from the Safety Office and that the panel report to the Shuttle Program Manager. The Chief of Headquarters Operations Safety Branch serves as advisor to the panel; and the panel chairman, who is Assistant Manager for NSTS Operations, reports organizationally to the Deputy Director, NSTS Program. These two factors satisfy the intent of the Commission recommendations while maintaining maximum independence for the panel in the conduct of its activities.

The panel has met ten times since January 1987 and has reviewed the flight safety programs at several NASA centers, United Airlines, the Air Force Flight Test Center, and the Air Force First Tactical Fighter Wing. Key flight safety officials at each of these locations were interviewed to compare the principles, functions, and capabilities of NASA's safety organization with those of our nation's best aviation safety organizations.

A report detailing the results of this survey with recommendations will be available in July 1987. The report will recommend enhancements to the training, certification, and management support given to the program safety engineers, a more aggressive mishap investigation and reporting system, and development of a viable flight safety program.

IMPROVED COMMUNICATIONS

Safety-of-Flight Communications

The Shuttle management structure, with the element project managers reporting programmatically to the Director, NSTS, and the regular meetings of the Office of Space Flight Management Council will minimize the potential for management isolation observed by the Commission. The new organization, along with the revised launch constraint process discussed below, will ensure that vital program and safety-related issues are elevated to the proper program management level for resolution.

Launch Constraints

The NSTS Program is establishing a formal process for identifying and defining launch constraints. This process will use a centralized, program-wide, problem reporting system to identify hardware and software discrepant conditions, from component acceptance testing through mission completion and postflight inspection. This system, discussed in detail in the response to Recommendation IX, will be initialized and maintained by the Deputy Director, NSTS Program. Element project managers will recommend launch constraints based on the performance of their systems. Other organizational elements, including SRM&QA, may also recommend constraints.

The Deputy Director, NSTS Program, will be responsible for evaluating proposed launch constraints and recommending their disposition. Approval for establishment, removal, and waiver of launch constraints will be the responsibility of the Director, NSTS. Launch constraints for each mission will be reviewed at the flight readiness review (FRR).

Flight Readiness and Mission Management Team Reviews

Major meetings leading to a decision to launch are the flight readiness and mission management team (MMT) reviews. The FRR, held 2 weeks before launch, is chaired by the Associate Administrator for Space Flight, with all senior program and center management as well as contractor officials in attendance. Each project manager is required to assess his readiness for launch by considering hardware status, problems encountered during launch processing and their resolution, launch constraints, and open items. Each NASA project manager and the respective element contractor is required to sign the Certificate of Flight Readiness, stating their readiness for launch, at the FRR.

The mission management team convenes at the beginning of terminal launch count and meets formally on launch minus 1 day (L-1) for final review of launch readiness. The MMT reports to the Deputy Director, NSTS Operations, and is composed of the management personnel responsible for launch- and mission-related decisions. Each project element and contractor will sign an endorsement to the certificate of flight readiness statement, at the L-1 day MMT meeting, that reaffirms their readiness for launch. SRM&QA personnel will be involved in the FRR, L-1, and other key decision-making meetings prior to launch and during the mission. The proceedings of both the FRR and MMT will be recorded, and formal minutes will be published.

Flight Crew Operations Directorate Participation

The Flight Crew Operations Directorate is now designated as a project element. The director or his designated representative is a participant in the FRR and a member of the MMT. He will certify that the flight crew is prepared for launch and that the crew has no unresolved issues related to the planned mission or flight hardware. The flight crew commander or his designated representative will attend the FRR.

Integrated Schedules

Overall management visibility and communications are being improved through development of a series of integrated program schedules. These schedules, based on weekly detailed input data from each element project and the NSTS Engineering Integration Office, have improved program management awareness of interrelated tasks and critical program paths to meet significant program milestones.

Recommendation III

Presidential Commission Recommendation III

Criticality Review and Hazard Analysis. NASA and the primary Shuttle contractors should review all Criticality 1, 1R, 2, and 2R items and hazard analyses. This review should identify those items that must be improved prior to flight to ensure mission success and flight safety. An Audit Panel, appointed by the National Research Council, should verify the adequacy of the effort and report directly to the Administrator of NASA.

NASA IMPLEMENTATION OF RECOMMENDATION III

FAILURE MODES AND EFFECTS ANALYSIS/CRITICAL ITEMS LIST REVIEW

NASA is reviewing all NSTS components to determine that all critical items which must be improved prior to flight have been identified and that corrective actions are under way.

A failure modes and effects analysis (FMEA) is performed on each component of the Shuttle system to identify hardware items that are critical to the performance and safety of the vehicle and mission. This analysis begins with an identification of the functional components of each system and a determination of the potential modes of failure for that component. Postulated component failure modes are then analyzed to determine the resulting performance of the system and to ascertain the worst-case effect that could result from a failure in this mode. Items are categorized according to the worst-case effect of the failure on the vehicle, crew, and mission.

The Critical Items List (CIL) is a listing of components and their failure modes which, if they fail in one of the potential modes identified in the FMEA, could result in loss of vehicle, life, or mission. The CIL also includes items that could fail in one mode and result in loss of redundant systems capability, items whose failure mode is not readily detectable in flight, and redundant systems in which a single failure may result in loss of the total system capability.

Critical items with these failure modes must be subjected to design improvements or to corrective action to meet the program redundancy requirements, or a waiver must be submitted to document the rationale for retaining an item that does not meet the requirements. Data elements included in the rationale include design, test, and inspection data, failure history, and operational experience. An approved waiver must support the decision to accept the risk represented by the critical item and ensure that maintenance, test, or inspection procedures will minimize the potential occurrence of the failure.

The hazard analysis (HA) is another analytical tool used to assess the risk resulting from hazardous conditions that could develop while operating and maintaining the system hardware and software. In addition to evaluating the risk resulting from the failures identified in the FMEA process, these analyses identify the presence of other potential risks caused by the environment, crew-machine interfaces, and mission activities.

These hazards and their causes are reviewed to identify areas where hazard elimination or control methods may be achieved by additional design, procedural changes, or operational constraints. Any hazards remaining after all feasible design or procedural corrective efforts are implemented are termed accepted risks and require review and approval by the Director, NSTS.

Each NSTS project and its prime contractor is conducting a review to verify the completeness and accuracy of the FMEA/CIL for the current design. A similar evaluation of all element and integrated system-level hazard analyses has been initiated. All waivers required for items whose failure modes would result in loss of vehicle, life, or mission have been rescinded and must be resubmitted to the Director, NSTS, for approval.

The NSTS has standardized the procedures for preparation of the FMEA/CIL and for documenting the waiver-retention rationale. These procedures, documented in NSTS 22206, Instructions for Preparation of Failure Modes and Effects Analyses and Critical Items List, provide detailed instructions, data elements, and ground rules emphasizing standardization and commonality throughout the program.

Figure 18 describes the evaluation process for the FMEA/CIL. Items subjected to FMEA review are reflected in one of five major criticality classifications commensurate with the failure mode. These classifications are defined in Table 2.

Independent contractors are conducting parallel reviews of the FMEA/CIL for each element and reporting the results of their assessments to the respective element project manager and to the Director, NSTS. These reviews emphasize any analysis results that differ from those identified by NASA or the element prime contractors. These independent contractors are listed in Table 3.

The FMEA/CIL review requires three actions to be taken for each hardware element: (1) the failure modes, causes, and related effects must be identified and documented, (2) the criticality of each mode must be developed, and (3) the retention rationale for each waiver must be established. Special effort is directed to identifying design enhancements, operational/procedural checkout changes, or software additions that reduce the criticality and/or minimize the risk of the potential failure mode.

NASA and the contractor jointly review

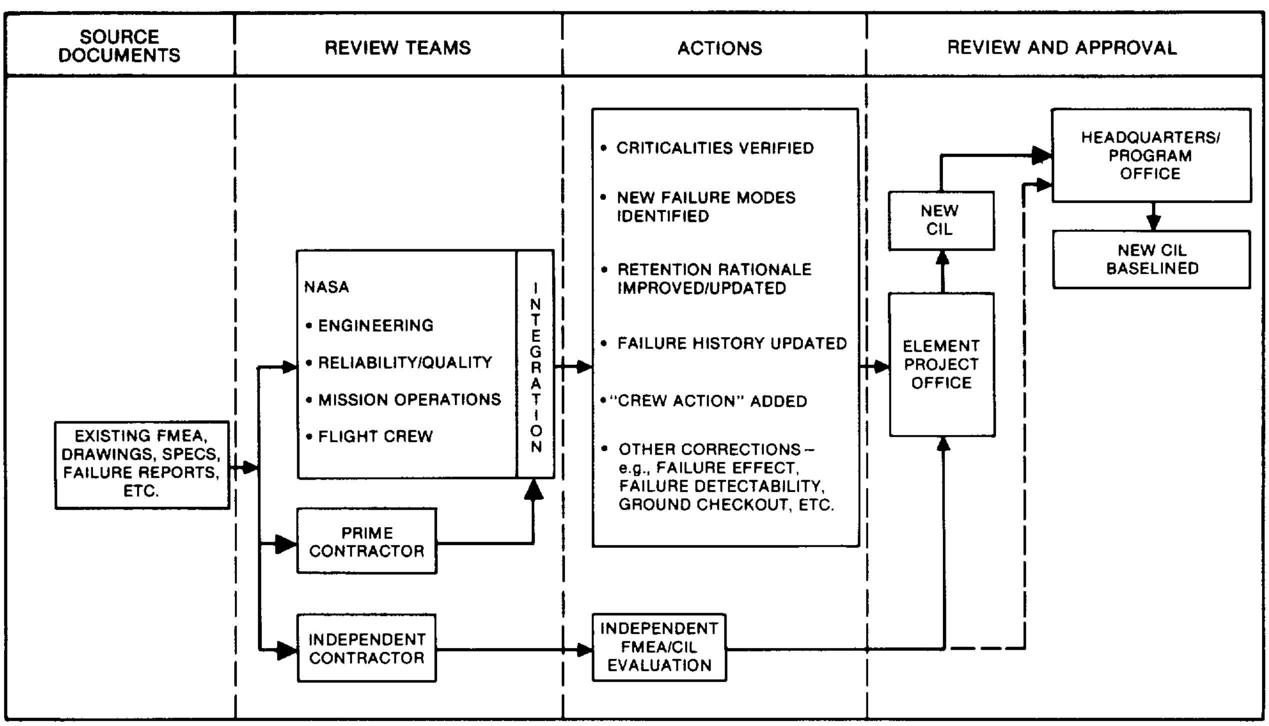


Figure 18. FMEA/CIL Evaluation Process

Table 2. FMEA/CIL Criticality Classification

Criticality Level	Effect of Failure
1	Loss of life or vehicle
1R	Failure of all redundant hardware items could cause loss of life or vehicle
2	Loss of mission
2R	Failure of all redundant hardware items could cause loss of mission
3	All others

the results of the FMEA/CIL evaluation and identify significant items for review by the element project offices. Items such as newly identified critical items, changes in criticality, changes in the redundancy verification requirements, or changes in the flight documentation require management approval prior to program acceptance.

As each element project completes its FMEA/CIL evaluation, the results are submitted to the Program Requirements Control Board (PRCB) for approval. The presentation includes significant issues resolved during the project reviews, new CIL items or those with changed criticality classifications, critical item waiver-retention rationale, and assessments from the independent contractor reviews.

The PRCB is co-chaired by the Director, NSTS, and the Deputy Director, NSTS Program. After the board presentation, a directive is issued that documents items for which waivers have been granted and lists actions assigned by the PRCB. Each critical item, along with its approved waiver, is maintained by the NSTS Program, and any subsequent changes affecting the CIL must be approved by the Director, NSTS.

An NSTS Oversight Group, consisting of safety, reliability, and quality assurance personnel from each center, ensures that prime contractor reviews are consistent and conform to the evaluation plan. This review group has visited the orbiter, external tank (ET), and Space Shuttle main engine (SSME) prime contractor facilities, the Kennedy Space Center (KSC) vehicle processing organizations, and the Marshall Space Flight Center (MSFC) Spacelab Project Office. The solid rocket motor (SRM) prime contractor's facility will be visited before the critical design review of the redesigned hardware. SR&QA representatives from the NSTS Program Office are supporting the ongoing FMEA/CIL activities at each center to ensure that reviews are performed in accordance with program guidelines and requirements.

Table 3. Critical Item Review Teams

Shuttle Element	Prime Contractor	Independent Review Contractor
Orbiter	Rockwell International, Space Transportation Systems Division	McDonnell Douglas Astronautics Company, Houston Division
External tank	Martin Marietta, Michoud Aerospace Division	Rockwell International, Space Transportation Systems Division
Solid rocket motor	Morton Thiokol, Inc., Wasatch Operations	Martin Marietta, Denver Aerospace Division
Solid rocket booster	United Technologies Corp., United Space Boosters, Inc.	Martin Marietta, Denver Aerospace Division
Space Shuttle main engine	Rockwell International, Rocketdyne Division	Martin Marietta, Denver Aerospace Division

HAZARD ANALYSIS REVIEW

Each project office, its prime contractor, and the independent contractors are evaluating all hazard analyses and reports to verify the completeness and accuracy of the safety analysis for the NSTS design and operational use. Hazards are categorized as controlled (by design, procedure, etc.) or as an accepted risk. Figure 19 describes the evaluation process for the hazard analyses.

Each hazard analysis assessment is being conducted in accordance with the guidance provided in NSTS 22254, Methodology for Conduct of NSTS Hazard Analyses, which defines the policy and procedures required for preparing hazard analyses, reports, and mission safety assessments.

The HA reviews are being conducted in a manner similar to that used in the FMEA/CIL review process. NASA and the element prime contractors are assessing the systems hazards, and the integration contractor is assessing potential hazards that cross element interfaces. The independent contractors are performing similar reviews and reporting directly to the projects and to the NSTS Program Office.

The HA assessment consists of a technical safety evaluation of the source material used for all analyses, studies, and investigations conducted from the beginning of NSTS flights. Each subsystem assessment ensures that all hazards have been identified, that dispositions are accurate, and that identified risks are acceptable. Final results of the evaluation will be submitted to the responsible project for review.

At the conclusion of the hazard analysis reviews, all open hazards, accepted risk candidates, or controlled hazards whose cause or effect crosses element interfaces, and the substantiating data and closure rationale, will be forwarded to a Senior Safety Review Board. This board will evaluate all submitted hazards and forward accepted risk candidates to the PRCB for approval by the Director, NSTS.

ELEMENT INTERFACE FUNCTIONAL ANALYSIS

In addition to the FMEA/CIL/HA reviews, the NSTS is reviewing and updating the element interface functional analyses (EIFA's) for all flight elements. EIFA's are analyses of various functional failure modes that can occur at element-to-element interfaces as a result of a hardware failure in either element. The purpose of these analyses is to correlate element hardware failures with failure modes at the element interface to determine the effect on the mission, vehicle, or crew safety. This activity ensures that the hardware FMEA/CIL's have the correct criticality classification.

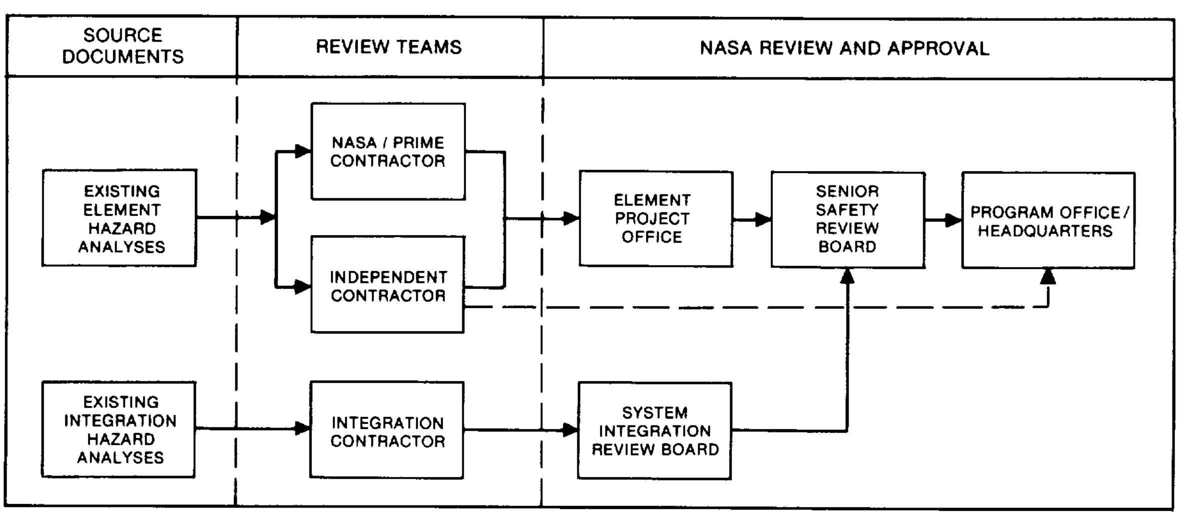


Figure 19. Hazard Analysis Evaluation Process

EIFA's have been conducted on ET/orbiter, SSME/orbiter, and SRB/ET/orbiter interfaces. These analyses have been reviewed by NASA and the systems integration contractor, and the results are under evaluation by the element project offices and the NSTS Engineering Integration Office. When this review is completed, the finalized EIFA's will be presented to the PRCB for formal approval.

NATIONAL RESEARCH COUNCIL AUDIT

The Shuttle Criticality Review and Hazard Analysis Audit Committee of the National Research Council (NRC), chaired by retired USAF General Alton Slay, reports directly to the NASA Administrator and is responsible for verifying the adequacy of the proposed actions for returning the Space Shuttle to flight status (see Appendix F for panel membership and a summary of responsibilities).

The committee has discussed the FMEA/CIL/HA reevaluation process with representatives from NASA Headquarters, JSC, KSC, and MSFC. Meetings have been held at the centers and at Rockwell International's Space Transportation Systems and Rocketdyne divisions; Morton Thiokol; United Space Boosters, Inc.; Sundstrand Corporation; and NRC Headquarters. The committee is evaluating the adequacy of the review process, checking for continuity across all elements of the program, and reviewing changes that NASA and its contractors have made since the accident.

A preliminary report was submitted to the NASA Administrator on January 13, 1987, indicating that the committee has been favorably impressed with the results obtained from the FMEA/CIL and hazard analysis processes. While the committee's general impressions were favorable, it did make some suggestions for improvements. In summary, these suggestions are: (1) Criticality 1 and 1R items should be assigned priorities based on the probability of occurrence; (2) since many of the Criticality 1 and 1R items differ substantially in terms of the probability of failure, NASA should consider modifying the definition of critical items to account for these differences; (3) NASA should incorporate its present system review procedures into an integrated system assessment process coupled closely with the FMEA/CIL reevaluation now being undertaken; (4) linkage between the STS engineering change activities and the FMEA/CIL/HA processes should be provided.

NASA has responded to these suggestions in the following manner:

1. Several candidate systems for prioritizing critical items have been evaluated by each of the projects. A hybrid system has been developed that incorporates the positive features of the candidate systems and specifically addresses probability of occurrence. The approach can be overlaid on the existing FMEA activity with minimum perturbation, providing an effective measure of relative risk.

   In parallel with the development of prioritization techniques, an effort is under way to determine the applicability of probability risk assessment to the FMEA/CIL process. This technique is used in the nuclear power industry to provide relative-risk assessments. Two firms with expertise in probability analysis have been selected to perform detailed assessments of the orbiter auxiliary power unit and the main propulsion engine pressurization system. A decision to apply probability analysis techniques to other systems of the program will depend on the results of these assessments.
2. The FMEA/CIL prioritization process will provide the necessary program focus and more definitive definitions in response to the committee's concern expressed in their second suggestion.
3. Since the accident, NASA has reemphasized its risk management effort. An important feature of the revised effort is a "systems engineering" approach that integrates the various elements of hardware and software failure analysis. Further discussion of risk management is included in the response to Recommendation IV.
4. Engineering changes are processed through the same project and program control boards that conduct and approve the reviews of the FMEA/CIL. Each

change request will be assessed to determine if it affects any Criticality 1 or 2 hardware to ensure that the required linkage is provided.

The NRC audit committee is reviewing additional areas to identify potential methods of reducing risk. These include the design qualification and flight certification processes, launch commit criteria and waiver policy, and the generation, review, and approval of retention rationale for waivers to critical items.

Also being reviewed are the overall safety, reliability, maintainability, and quality assurance program, the definition of structural analysis requirements, the establishment and verification of analyses for margins of safety, the risk management processes for software, and the processes for analyzing payload safety.

Interim findings and recommendations from these reviews will be submitted to the NASA Administrator through letter reports, as required. The final report, anticipated in 1987, will include an assessment of the procedures reviewed and recommendations for improving the Shuttle risk management system. As reports are received, any recommendations included will be reviewed by NASA and responses will be provided to NRC.

Recommendation IV

Presidential Commission Recommendation IV

Safety Organization. NASA should establish an Office of Safety, Reliability and Quality Assurance to be headed by an Associate Administrator, reporting directly to the NASA Administrator. It would have direct authority for safety, reliability, and quality assurance throughout the agency. The office should be assigned the work force to ensure adequate oversight of its functions and should be independent of other NASA functional and program responsibilities.

The responsibilities of this office should include:

- The safety, reliability and quality assurance functions as they relate to all NASA activities and programs.
- Direction of reporting and documentation of problems, problem resolution and trends associated with flight safety.

NASA IMPLEMENTATION OF RECOMMENDATION IV

NASA has established an Office of Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA). A new position, Associate Administrator for SRM&QA, has been established, reporting directly to the NASA Administrator. Mr. George Rodney, previously with the Martin Marietta Corporation, was appointed to fill this position. The NASA Office of the Chief Engineer was abolished, and the appropriate functions and resources of that office were transferred to the Associate Administrator for SRM&QA.

In December 1986, the Administrator signed and published NASA Management Instruction 1103.9A, Roles and Responsibilities—Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA). This instruction (Appendix G) established the objectives, organizational setting, and responsibilities of the SRM&QA program, and provided for a separate and independent assessment function.

The following goals have been set for this office:

- Establish the SRM&QA function as an aggressive contributor and as a check and balance for the overall NASA operation.
- Provide an independent assessment of the NASA development and operating process—design, development, manufacturing, procurement, test, and operations.
- Develop and ensure implementation of firmly defined policies and procedures for SRM&QA on a uniform basis throughout the agency.
- Develop an SRM&QA work force that is manned with quality people who are properly trained and equipped, who are dedicated to superior performance and the pursuit of excellence, and who will provide the leadership in implementing this goal of excellence throughout the NASA/industry work force.
- Provide, at all times, oversight directed toward 100-percent operational success in a safe manner.

A short-range (2-year) SRM&QA Program Plan has been published, and preparation of a long-range (5-year) program plan and a strategic (10-year) plan are under way. The short-range plan requires each NASA center to develop plans that document the goals and determine the resource requirements necessary to establish and maintain effective center programs.

Five areas have been identified that will assist in accomplishing the goals of the new organization. Each is defined in the master plan, together with a schedule of milestones to be met in the implementation process. The following is an overview of each element and its role in the overall achievement of the SRM&QA mandate.

ORGANIZATION

The NASA Headquarters SRM&QA organization is shown in Figure 20, while Figure 21 reflects the previous organization of the Office of Chief Engineer. The center organizations are shown in Figures 22, 23, and 24. The Reliability, Maintainability, and Quality Assurance Division, the Safety Division, and the Programs Assurance Division constitute the core organizational elements of the Headquarters Office. The first two of these divisions establish, document, and maintain the SRM&QA policies, plans, procedures, and standards for the agency. The Programs Assurance Division provides the necessary day-to-day support to the program offices, reporting to the Associate Administrator on the status of those programs.

The Deputy Associate Administrator for Systems Assurance is responsible for ensuring that problems/trends are identified and communicated to the proper management level and that a strong system of independent checks and balances is established at headquarters and the centers. Other functional responsibilities include cognizance and control over system assessments, audits, and agency risk management.

The maintainability functional responsibility has been integrated into the headquarters and Marshall Space Flight Center (MSFC) organizations. Johnson Space Center (JSC) and Kennedy Space Center (KSC) are increasing their emphasis on this function and assessing where it should be located in their organizations.

The Space Flight Safety Panel was established to independently assess flying safety and the mission preparation and operations processes. Membership on this panel includes astronaut Bryan O'Connor, chairman, and a JSC flight director, KSC test director, and MSFC mission manager. The

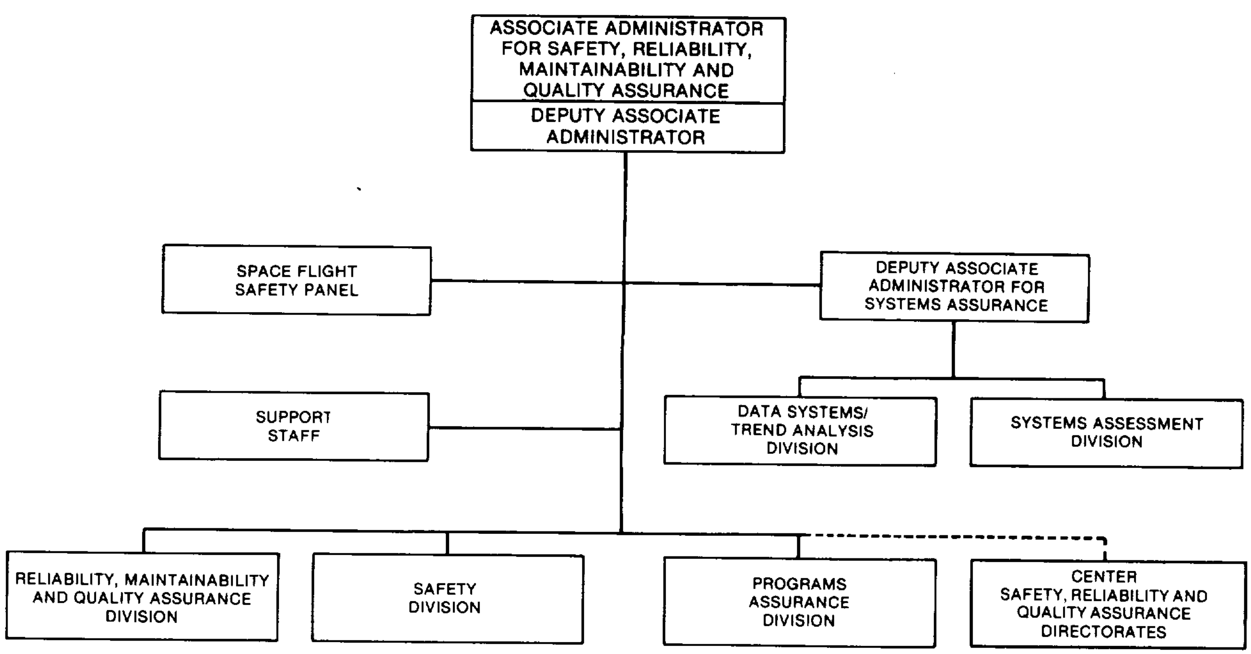


Figure 20. SRM&QA Organization— NASA Headquarters

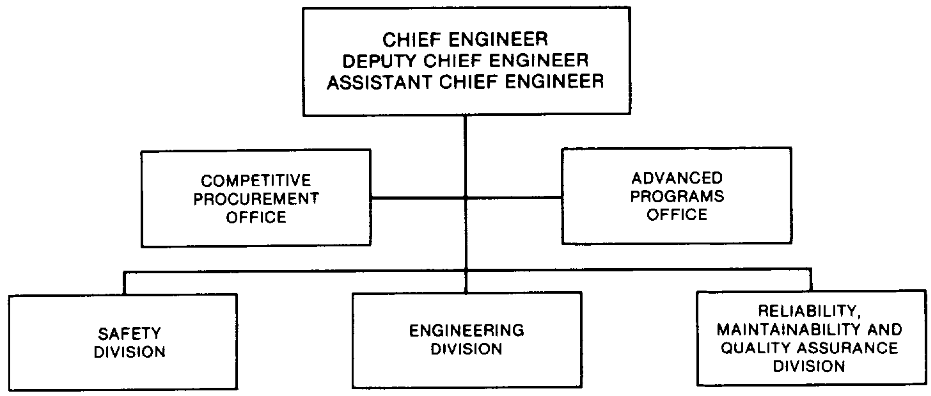


Figure 21. Office of Chief Engineer—NASA Headquarters (Pre-STS 51-L)

panel reports to the Associate Administrator for SRM&QA, who provides the Chief, Operational Safety Branch, as an advisor to the panel. This panel provides the Associate Administrator for Space Flight with an independent assessment of NSTS operational issues.

RESOURCES

The SRM&QA organization is defining its resource requirements in terms of manpower and budget. A plan to upgrade the skills of the SRM&QA professional staff and to establish a career development intern pro-

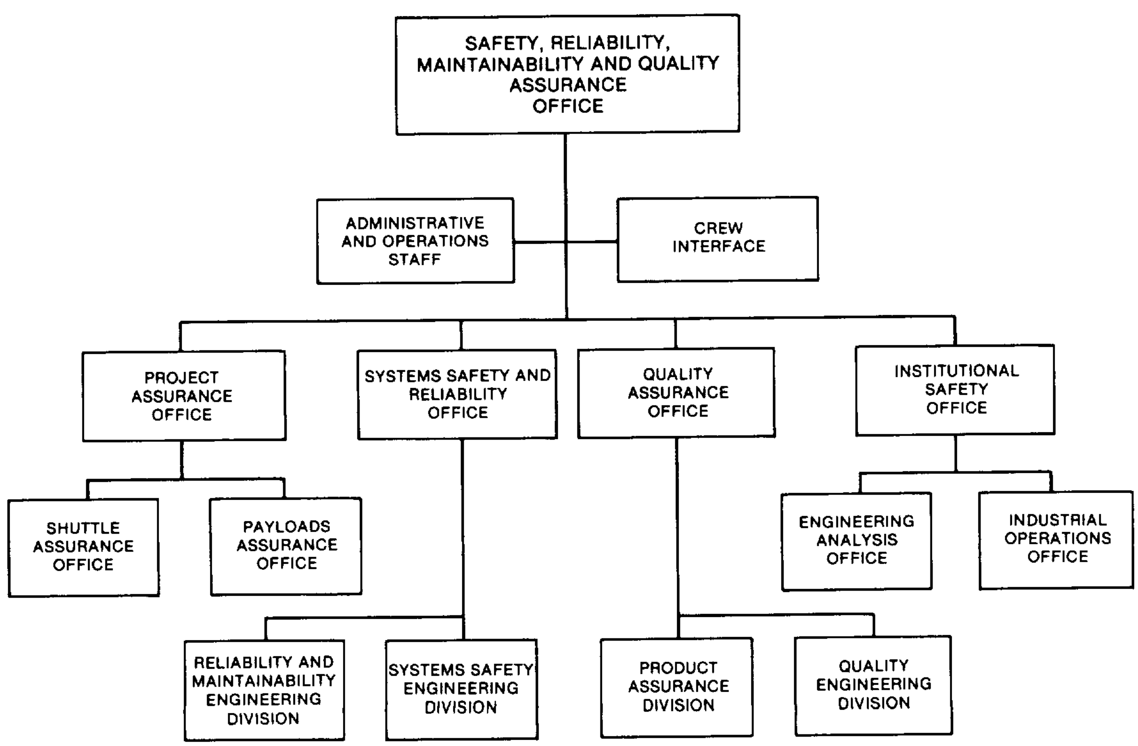


Figure 22. SRM&QA Organization— Marshall Space Flight Center

gram is being developed to attract high-quality people to the agency. Recruitment of personnel to maintain adequate oversight at Government and contractor facilities and to provide the proper levels of internal coordination and review has been initiated.

A preliminary manpower analysis has been conducted to determine NASA's total SRM&QA personnel requirements, including civil service, support contractor, and Department of Defense (DOD) quality inspectors. This analysis has resulted in an estimate of baseline and projected requirements through Fiscal Year 1988. The NASA civil service SRM&QA work force will increase by approximately 24 percent in 1987 and is expected to increase by about 35 percent in 1988. The analysis is being continued to determine the long-term requirements.

The centers are providing periodic reports on requirements and authorizations to the Associate Administrator for SRM&QA. These reports provide early identification of changes in requirements and highlight problems in acquiring qualified personnel, so that appropriate action can be taken. The centers will develop similar insight into their major contractors' SRM&QA capabilities to ensure that viable programs are maintained or developed.

POLICIES AND GUIDANCE

One of the primary objectives of the SRM&QA Office is to establish firmly defined policies and procedures that will ensure the uniform application of standards throughout the agency. Areas being emphasized include systems assurance, safety, problem reporting and trend analysis, systems assessment, software assurance, nondestructive evaluation, and an electronic parts standardization program. Each of these areas is integrally tied to NASA's overall risk management policies.

The basic concept of the NASA risk management program is to maximize safety and reliability within program constraints and operational limitations. New initiatives that provide a stronger, more centralized risk management capability have been initiated. Specific risk management directives and an overall risk assessment methodology are being developed.

Problem reporting, corrective action, and trend analysis are closely related to risk management. NASA Management Instruction 8070.3, Problem Reporting and Corrective Action, and Trend Analysis Requirements, establishes the responsibilities for this activity. The Deputy Associate Administrator for

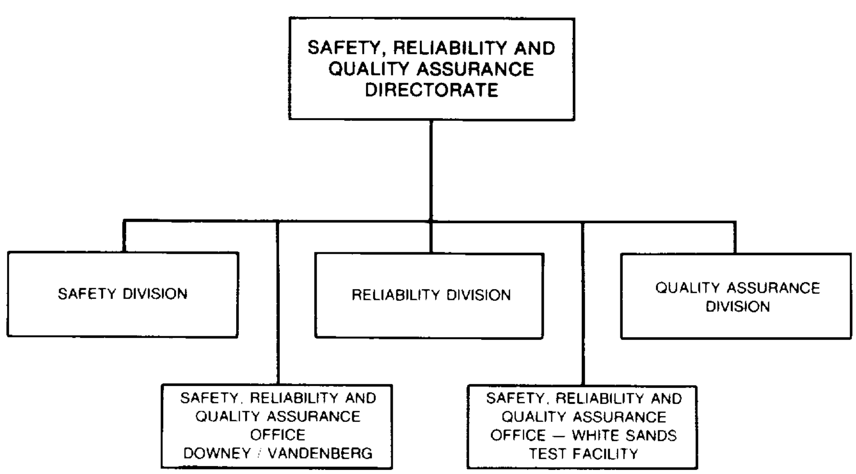


Figure 23. SR&QA Organization— Johnson Space Center

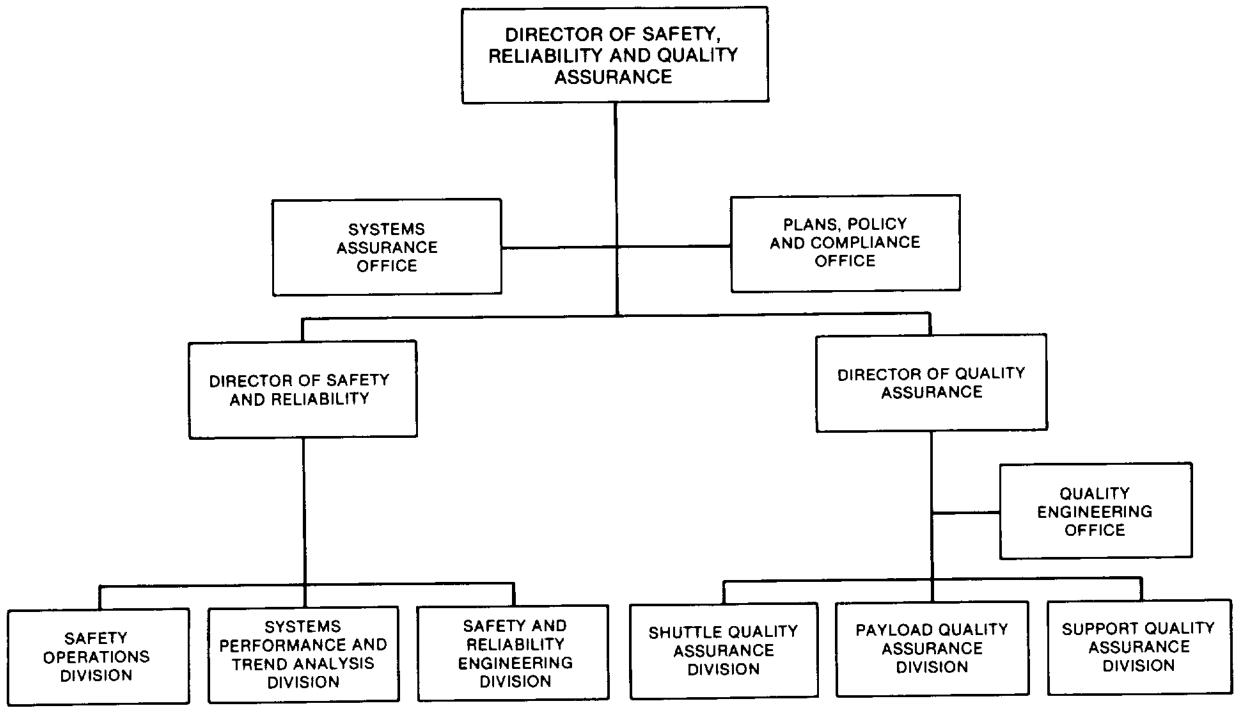


Figure 24. SR&QA Organization—Kennedy Space Center

Systems Assurance, whose organization contains the Data Systems/Trend Analysis Division and Systems Assessment Division, is responsible for implementing this activity. An intercenter problem reporting and corrective action information system and a program compliance assessment status system are being developed to assist in the analysis and reporting of significant problems and trends.

This problem reporting and corrective action data base, developed by SRM&QA, is scheduled to become fully operational in October 1987. The system will contain all relevant "problem reporting" data for the NSTS and will provide access to the individual problem reporting data bases at JSC, KSC, MSFC, and selected contractors.

A set of common data elements has been established to enable each center to display and analyze information collected at the other centers. This technique will increase visibility into significant problems and improve the ability to perform independent technical assessments and in-depth trend analyses.

The System Integrity Assurance Program (SIAP), being developed by the NSTS and described in the response to Recommendation IX, will contain information on requirements verification, risk decision/hazard analyses, integrated problem assessments, trend analysis, and failure modes and effects analysis (FMEA)/Critical Items list (CIL). The intercenter problem reporting system will interface with this system and will be the basis for the integrated problem assessments. SRM&QA is participating in the development of requirements for the SIAP and will utilize information from it to support independent technical assessments.

Development of nondestructive evaluation (NDE) methods for inspection, assessment, and control of hardware is crucial to cost-effective risk analysis. An NDE Center of Excellence at the NASA Langley Research Center has been established to develop the needed tools. The major goals of the center are to develop one new NDE method or technique for field use each year and to develop and strengthen workmanship standards.

The NDE process being developed will enhance cost-effective methods for inspection, including assessment and control of hardware, and surveillance of manufacturing processes. Improvements in the NDE process are expected to provide a means of ensuring quality and integrity of products that have traditionally been difficult to test or that required testing to destruction.

The requirements for on-orbit repair/maintenance indicate the need to establish a policy on maintainability and its relationship with reliability and systems engineering. The specific engineering and analytical requirements for maintainability will be defined and published later this year. A preferred methodology, and a series of training courses associated with it, is being developed.

Software assurance is an ongoing activity within the Reliability, Maintainability, and Quality Assurance Division. A software acquisition life-cycle management methodology and software documentation standards are being developed, as are guide books and training courses for software acquisition and product assurance functions.

POLICY IMPLEMENTATION AND PROCEDURES

A milestone schedule for release of procedures to implement the SRM&QA policies and guidelines has been developed. The reviews, reassessments, reports, and other activities necessary to ascertain status, progress, and problem areas are identified in the schedule. This schedule will assist in reviewing the implementation of policies, directives, and guidelines, and in determining any areas that require modification.

A significant-problem report (SPR) has been developed to ensure adequate communication and assessment of problems and trends in the agency. Initial use of this report will be devoted to the Space Shuttle and associated payloads; however, it will be expanded in the future to include other areas. The categories of problems shown in Table 4 will be considered in the preparation of an SPR.

The Office of the Associate Administrator will play an integral role, along with center SRM&QA offices, in the mission planning process. The center offices will be involved in the review of the day-to-day detailed planning process. The Headquarters Office will monitor the overall planning process, ensuring that such areas as schedule, overtime rates, spares availability, and reviews do not adversely affect safety. Particular attention will be given to identifying any trends or indications of potential problem areas that result in undue schedule pressure.

A plan for an enhanced safety program is being developed that includes the risk management safety program, the STS safety program, and the Space Station safety program. Specific programs focusing on landing and crew safety are being instituted.

An STS Safety Risk Assessment Ad Hoc Committee has been formed to review center and contractor risk assessment procedures and to provide comments and criteria for policy documents.

A standardized mishap reporting and corrective action system is being implemented agency-wide and will become fully operational by early next year. The system requires management review and approval of all corrective action plans and provides a mechanism for disseminating lessons-learned summaries through electronic communications.

A supplemental safety information channel, the NASA safety reporting system, is being implemented to enable NASA and contractor personnel to notify SRM&QA of safety problems or hazards that could potentially result in loss of mission capability.

Using this system, individuals will be able to communicate safety concerns to an independent agent when, in their opinions, standard reporting channels lack the proper degree of response to a critical problem. This system, patterned after the FAA's aviation safety reporting system, is not intended to replace normal management channels for reporting hazards or safety concerns.

A NASA safety information system is being established. This system and a comprehensive review and upgrade of directives, handbooks, guidelines, and manuals are part of the overall strengthening of NASA's safety program. The safety information system will provide a complete, readily accessible, centralized source of agency-wide information. It will compile information to allow the tracking and evaluation of known safety concerns and for the detection and identification of safety concerns not previously known. The system will respond to a wide range of specific and general requests from headquarters, field installations, programs, and contractors. It will support risk, risk/benefit, and risk/cost/benefit analyses in the NASA risk management program.

The Associate Administrator for SRM&QA has developed guidelines for contract award fee criteria. Center offices will participate in award fee determinations and ensure that contractual provisions provide appropriate clauses and incentives to focus contractor attention and efforts on SRM&QA activities.

To guide and execute the SRM&QA goals and tasks successfully, close coordination and cooperation between NASA and its contractors must be maintained. The NASA Excellence Award for Quality and Productivity will continue to be given in recognition of outstanding contractors and subcontractors who demonstrate continuing improvement in hardware and/or service performance.

PROGRAM REVIEW/EVALUATION

Formal audits and evaluation of center, contractor, program, project, and special problem areas are planned. Audit teams composed of individuals from NASA, DOD, other federal agencies, and industry will be formed under the direction of the Deputy Associate Administrator for Systems Assurance. Team members will be selected for their experience and skills to ensure that thorough, comprehensive inspections and audits are performed.

Audit results will be reported to the Associate Administrator for SRM&QA and to the concerned center and program director. The NASA Administrator and appropriate associate administrators will be briefed on selected audit results. A corrective action response will be required from institutions, contractors, and programs on all unsatisfactory or marginal findings. Critical problem areas will be entered into a tracking system to monitor progress and ensure prompt and proper resolution.

These audits are intended to ensure compliance with the established policies, to ensure prompt and correct identification of

Table 4. Significant-Problem Report Source Data

NSTS: Open Criticality 1 and 1R problem reports, waivers, and associated trends **NSTS payloads or upper stages:** Open problem reports, waivers, and associated trends that have the potential for causing critical failure modes or hazards Selection guideline: SRM&QA management, in coordination with the management of other center organizations, will, at each reporting level, determine which problems in this category warrant the attention of the next-higher level of management.	**NSTS:** Unexplained anomalies on Criticality 1 and 1R hardware and software **NSTS payloads or upper stages:** Unexplained anomalies that have the potential for causing critical failure modes Selection guideline: all problems in this category should be included in the SPR.
NSTS: In-flight anomalies and trends/problems related to Criticality 1, 1R, 2, and 2R items Selection guideline: all problems in this category should be included in the SPR.	**NSTS and NSTS payloads or upper stages:** System safety trends or specific safety problems Selection guideline: SRM&QA management, in coordination with the management of other center organizations, will, at each reporting level, determine which problems in this category warrant the attention of the next-higher level of management.

any major problems, to provide assistance to other organizations for related SRM&QA programs, and to promote proper discipline among all NASA organizations.

New or revised safety policies are being developed in such areas as explosives, software, lasers, system safety, aviation, mishap investigation, radiation, range operations, facilities, and others. A major effort to establish software assurance policies and procedures is under way.

OTHER ACTIVITIES

A new Director of SR&QA has been named at each of the centers, reporting directly to the Center Director. At MSFC and KSC, the reliability and quality assurance functions have been removed from the engineering organizations and combined with safety in an organizational alignment similar to that which existed at JSC. SR&QA manpower has been increased at both MSFC and JSC and is being increased at KSC.

Several astronauts have been placed in key positions in the SR&QA offices, including that of Safety Director at JSC and the Safety Operations Branch Chief at NASA Headquarters. Other astronauts are monitoring safety-related activities at KSC and MSFC.

The new SRM&QA organization is participating actively and directly in specific NSTS activities, such as the hardware redesign, failure mode and effects analysis, critical item identification, hazard analysis, risk assessment, and space flight system assurance. This approach allows the NSTS Program line management at headquarters and in the field to benefit, on a continuing basis, from the professional safety contributions of an independent office without interrupting the two different reporting lines to top management.

Additional safeguards have been added by both the line project management and the SRM&QA organization to ensure that there is free, open, rapid communication upward and downward within all agency activities responsible for safety of flight.

Recommendation VI

Presidential Commission Recommendation VI

Landing Safety. NASA must take actions to improve landing safety.

- The tire, brake and nosewheel steering systems must be improved. These systems do not have sufficient safety margin, particularly at abort landing sites.
- The specific conditions under which planned landings at Kennedy would be acceptable should be determined. Criteria must be established for tires, brakes and nosewheel steering. Until the systems meet those criteria in high fidelity testing that is verified at Edwards, landing at Kennedy should not be planned.
- Committing to a specific landing site requires that landing area weather be forecast more than an hour in advance. During unpredictable weather periods at Kennedy, program officials should plan on Edwards landings. Increased landings at Edwards may necessitate a dual ferry capability.

NASA IMPLEMENTATION OF RECOMMENDATION VI

Prior to the accident, component and systems testing, simulations, and flight analysis results had identified a need to improve the landing system. The improvements included a requirement to increase brake capacity, eliminate mechanical and thermally induced brake damage, improve steering margin, and reduce the effects of tire damage or failure. Subsequent analysis, test, and a series of simulations conducted at the Ames Research Center vertical motion simulator in April 1987 addressed overall landing safety.

As a result of this analysis and test activity, several design improvements (Figure 25)

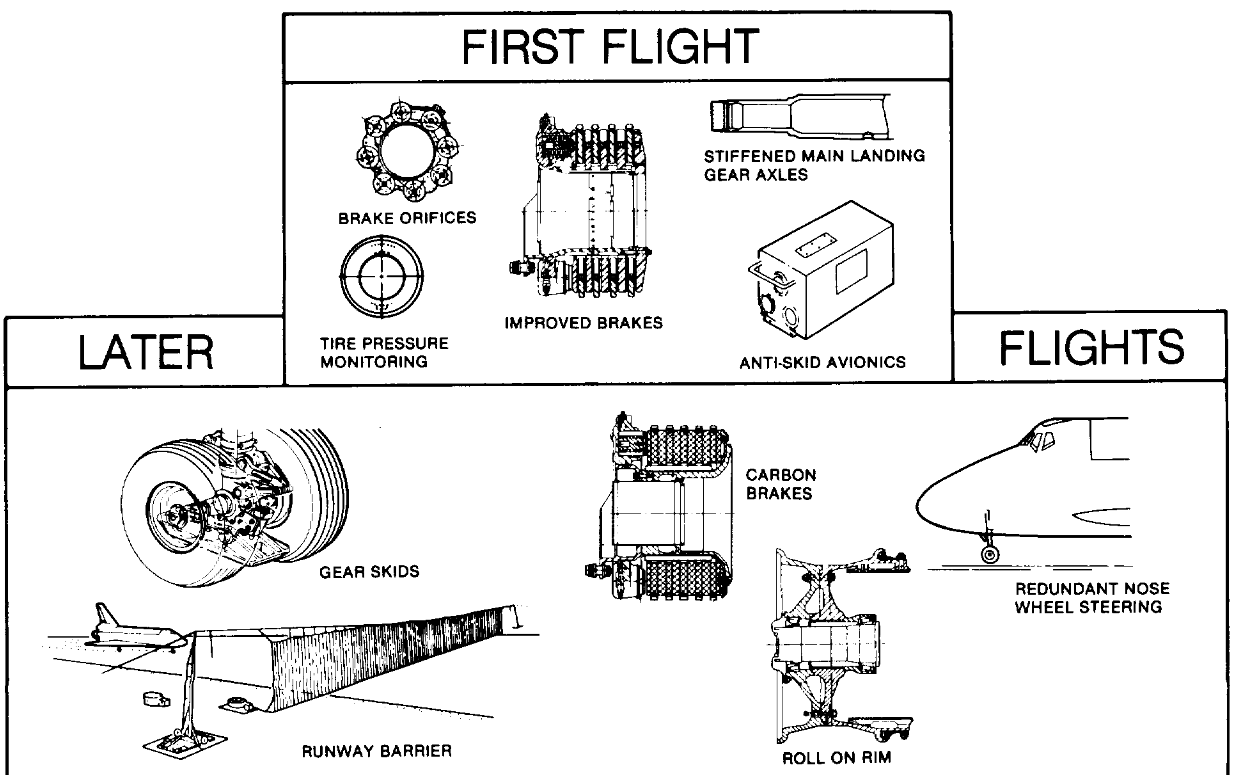


Figure 25. Landing System Safety Improvements

have been instituted to improve the margins of safety for the landing/deceleration system. Some of these improvements are modifications to existing designs and will be completed prior to the next flight. Other improvements involve the development of new designs to improve performance margins and the reliability of the overall system and, if certified and approved for flight, will be incorporated later in the program.

BRAKING SYSTEM IMPROVEMENTS

Two major brake improvement programs are currently under way: an interim brake system upgrade and a longer-term carbon brake development program. The interim program provides for an increased brake energy absorption capability, modification of the brake anti-skid system, modified brake wear-in procedures, installation of flow restrictors in the brake hydraulic piston housing, and a stiffened main gear axle.

The energy absorption capability of the brakes is a concern. Localized hot spots in the brake cause reduced stator strength in the structural load reaction path and result in stator failure. Additional material is being added to two of the three beryllium stators (Figure 26) to increase heat sink capability and reduce the temperature rise rate. This change will increase stator load reaction ability and minimize resultant wear.

Brake/anti-skid system tolerance buildups have resulted in unequal brake pressure application to adjacent brakes on the same landing gear strut. This pressure differential prevents full utilization of the brake capacity. Modification of the brake anti-skid system to provide an electrical adjustment method will ensure that the brake pressure is equalized or balanced. A second design modification will remove the anti-skid system sensory circuit that reduces the brake pressure to the opposite wheel if a flat tire is detected.

The thicker stators and the modified anti-skid system are expected to provide an overall brake system capacity of 65 million foot-pounds—an approximate 18-percent increase in energy absorption capacity over the present capability. Mission planning and

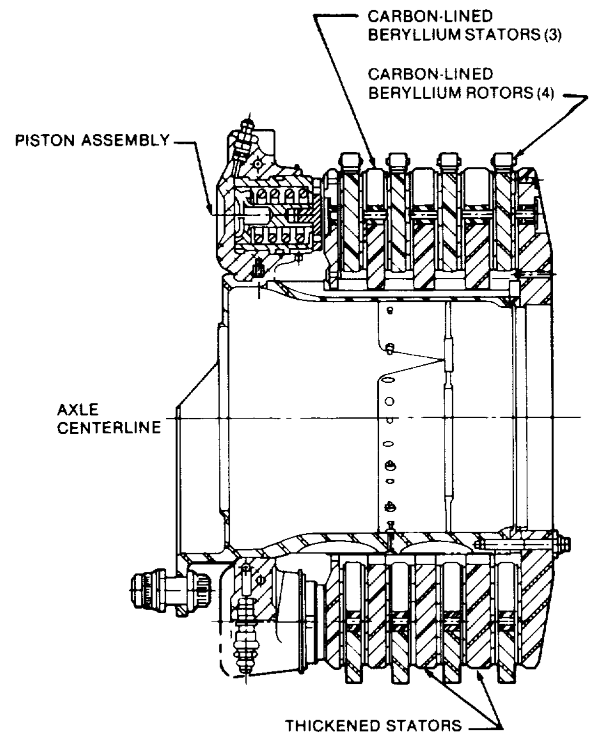


Figure 26. Improved Main Landing Gear Brake Assembly

landing performance analyses will continue to utilize a nominal energy capacity of 55 million foot-pounds, thus providing an additional margin of safety for landing.

The brakes will be exposed to wear-in runs with higher energy and pressure during acceptance tests at the supplier. This technique was used successfully for several flight brake sets prior to STS 51-L, with no indication of dynamically induced brake damage during subsequent landings.

Analysis of flight data collected on the STS 41-G mission indicated the need to restrict the free flow of hydraulic fluid within the brake piston housing to eliminate the potential for a "whirl" phenomenon that can cause major dynamic loads to be imposed on the brake. Six orifices (flow reduction devices) are being added to the brake hydraulic piston housing to provide the flow reduction and to reduce the dynamic loads and the resultant damage to the brakes.

Stiffer landing gear axles are being installed to reduce wheel/brake relative deflection and minimize the unequal brake loading and tire shoulder wear.

Each of these modifications to the landing system hardware is currently in work. The modified hardware will be analyzed, tested, and certified before being installed for the next flight. Engineering data obtained from instrumentation being added to the first flight vehicle will be used to analyze the overall brake system performance and to verify that these changes provide the desired safety margins.

A tire pressure monitoring system, similar to that used during prelaunch on flights STS-1 through STS-5, is being installed on all vehicles. This instrumentation provides redundant strain gages on the nose and main wheels to indicate tire pressure. The tire pressure data will now be available for in-flight monitoring by the flight crew and Mission Control Center. Knowledge of tire pressure prior to landing will enhance overall landing safety. If it is determined that a tire(s) has insufficient pressure to support the landing loads, steps can be taken to land on the safest runway for the particular situation.

Development of a structural carbon brake (Figure 27) is under way. The "structural" carbon brake utilizes the carbon material of each rotor and stator as the load-reacting member. The design incorporates an additional rotor and stator and will provide an energy absorption capability of 85 million foot-pounds, which represents an approximate 55-percent increase over the present design. Overall capability and performance margin of this brake will be demonstrated by ground testing to 100 million foot-pounds. Key milestones include a critical design review in July 1987 and the beginning of qualification testing in February 1988.

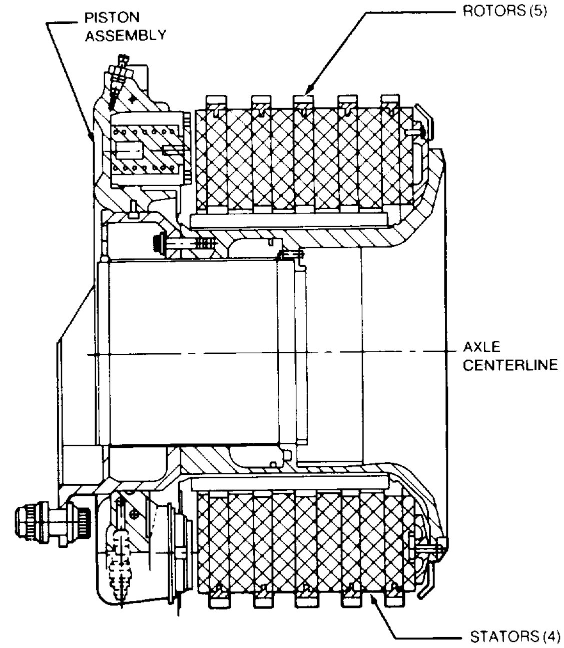


Figure 27. Future Main Landing Gear Carbon Brake Assembly

NOSE WHEEL STEERING

Nose wheel steering is used for directional control (steering) of the orbiter during a crosswind landing and roll-out or in the event of a blown tire (or tires). The current system has the capability to provide the required steering but lacks complete redundancy. Studies are under way to determine those features that could be incorporated into the system design to maximize redundancy. The current system is fail-safe in that several single failures can cause it to default to a free caster mode (no positive directional control), necessitating the use of differential braking to steer during roll-out. Design options being considered would enhance the system fault tolerance to a fail-operational/fail-safe condition.

TIRE IMPROVEMENTS

A tire improvement/runway surface study is now in progress to determine how to decrease the tire wear experienced during KSC landings, while maintaining an acceptable traction level in the event of landing on a wet runway. Because of the abrasive surface of the KSC runway, significant tire wear has been experienced at touchdown and during crosswind landings and roll-out.

Analyses are being performed to determine what changes can be made to the KSC runway surface to reduce tire wear, while maintaining a limited wet runway capability. These analyses include potential techniques for smoothing the surface, such as grinding, sandblasting, or painting. The program is committed to better understanding the contribution of the surface to tire damage and to determining the options for modifying the surface prior to resumption of planned end-of-mission landings at KSC.

Extensive tire tests have been conducted at the Aircraft Landing Dynamics Facility at the NASA Langley Research Center to obtain a data base for better understanding the orbiter tire wear and performance characteristics. This facility provides the capability to duplicate orbiter touchdown velocity, to simulate vehicle yaw angles experienced during a crosswind landing, and to simulate the tire loading during the landing roll-out. This capability, combined with the ability to change the runway surface finish, provides a base from which parametric tire-to-surface performance characteristics can be generated. The worn tires are then tested on a dynamometer at the Wright Patterson Air Force Base to determine the remaining useful life.

Modified tires were tested at the Langley facility. The modifications consisted of added tread rubber thickness and a change in the tread rubber compound to increase the wear-resistant properties of the tire. Test results were favorable, and analysis is continuing; however, any change to the tire would require complete verification and would not support the early flights.

OTHER STUDIES

An end-of-runway barrier and a drag chute are being assessed to determine their potential contributions to increasing landing margin and safety. Other studies are evaluating changes to orbiter landing procedures to minimize tire wear and landing gear support for a failed tire.

Orbiter Arresting System

An orbiter arresting system (runway barrier) is being developed. This system, which would be deployed approximately 600 feet from the roll-out end of the runway, is designed to safely stop a 260,000-pound orbiter traveling at 100 knots or less, without injury to the crew. A preliminary design review is scheduled for June 1987 and first installation is planned for no earlier than February 1988. No decision has been made on which runways would incorporate such a capability.

Drag Chute

An orbiter drag chute deceleration system study was initiated in October 1986. The study is determining the best location, method of attachment, size, and weight of a drag chute necessary to stop the orbiter within 7,500 feet after main gear touchdown.

Testing performed at the vertical motion simulator determined that use of a drag chute, deployed at touchdown, can reduce roll-out distance, improve handling qualities, and reduce tire loads and required brake energies. Orbiter installation design options for the drag chute are being assessed; however, no decision to install the system has been made.

Landing Gear Strut/Roll-on-Rim Capability

Other studies are under way to determine potential improvements for landing safety. These include analysis of gear skids attached to the landing gear struts to provide a protective wear surface if a tire fails (Figure 28); a strengthened wheel rim to provide a roll-on-rim capability in the event of tire(s) failure (Figure 29); and a main gear wheel spin-up technique to reduce the depth of the tire

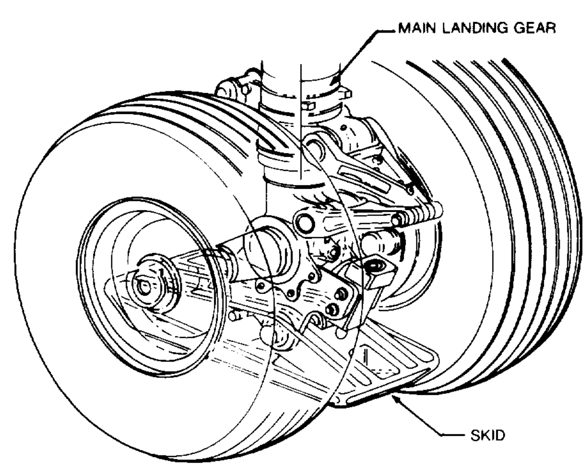


Figure 28. Main Landing Gear Skid

tread wear that occurs at touchdown. No decision to incorporate any of these potential improvements has been made.

Landing Gear Load Reduction

Methods for reducing the main gear roll-out loads, to minimize the potential for blown tires, are being assessed. Loads are generated by negative lift (aerodynamic down force on wings and fuselage) induced by the orbiter's nose-down rolling attitude. A computer software modification has been approved that will position the elevons automatically to a down position after nose wheel touchdown. This will reduce the load on the main tires and will improve the safety margins on the landing gear assembly.

LANDING CRITERIA

Integrated landing system testing will be performed to satisfy detailed test objectives during early flights scheduled to land at Edwards Air Force Base (EAFB). The results of laboratory and simulator testing and orbiter landings will be used to develop and refine the appropriate flight mission rules and crew procedures associated with landing. Total understanding of all performance data, successful resolution of all significant anomalies, and confidence in the enhanced weather prediction capability will be constraints to resuming planned end-of-mission (EOM) landings at KSC.

WEATHER

The Space Shuttle Weather Forecasting Advisory Panel, chaired by Dr. John Theon, was established by NASA Headquarters to review existing weather support capabilities and plans and to recommend a course of action to the NSTS Program. Included on the panel were representatives from NASA, the National Oceanic and Atmospheric Administration (NOAA), the Air Force, and the National Center for Atmospheric Research.

The panel examined skills, equipment, and techniques available to the Space Shuttle weather support staff. Panel recommendations included improvements to forecasting procedures, personnel policies, and data communications as well as technological improvements. Key proposed equipment changes included airborne sensors, to quantify precipitation in the Cape Kennedy area, and better wind forecasting equipment. NSTS representatives will continue to work with the advisory panel and with NOAA to ensure that the best forecasting equipment and procedures are available to the program.

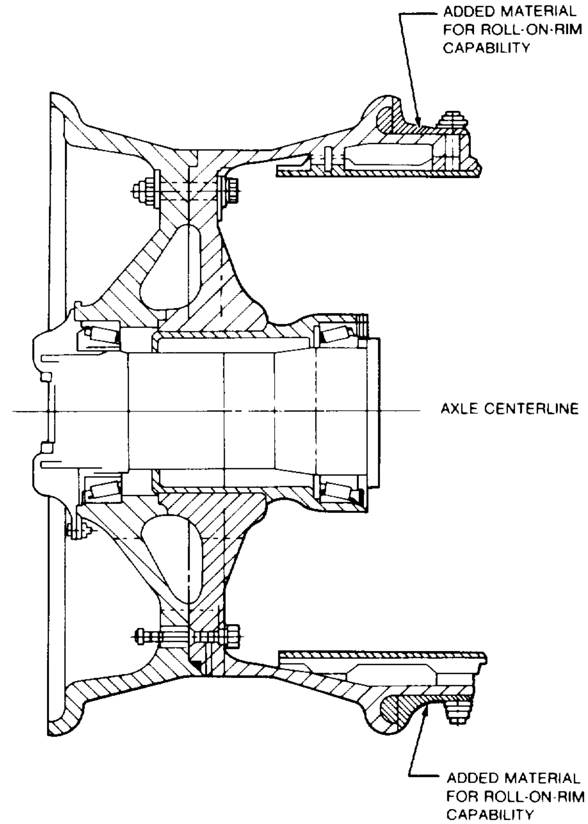


Figure 29. Proposed Roll-on-Rim Configuration

NASA has revalidated the statistical weather data base for all Space Shuttle landing sites and has established minimum weather measuring equipment requirements for EOM and abort sites. Equipment requirements not currently in place are being reviewed for future implementation.

For the transatlantic abort landing sites, the approved changes include the addition of both a ground-based and an airborne weather observer, availability of European weather satellite data at the Johnson Space

Center, and augmentation of on-site weather monitoring equipment such as remote sensing stations and balloon release and tracking equipment. The capabilities of continental United States landing sites are being assessed to ensure that weather decisions are made with accurate and timely data.

NASA has requested assistance from the National Academy of Sciences to identify concepts for equipping the Kennedy Space Center with the necessary instrumentation to provide a prototype forecasting facility capable of a 90-minute, high-confidence-level forecast.

A second objective being discussed with the National Research Council is a program that would encourage the research community to sponsor atmospheric activities, utilizing KSC as a test location, for the application of state-of-the-science meteorological forecasting techniques and technology. The council has appointed its Mesoscale Research Panel to address this request and to provide NASA with an implementation plan.

DUAL FERRY CAPABILITY

NASA has assessed the requirements and initiated budgetary actions for an additional Boeing 747 aircraft to provide an NSTS dual ferry capability. Funding for the aircraft modification kit used to attach the orbiter to the aircraft has been approved, and funding for an additional aircraft has been requested. With the availability of the second aircraft, the dual ferry capability will be operational by 1990.

Recommendation VII

Presidential Commission Recommendation VII

Launch Abort and Crew Escape. The Shuttle program management considered first-stage abort options and crew escape options several times during the history of the program, but because of limited utility, technical infeasibility, or program cost and schedule, no systems were implemented. The Commission recommends that NASA:

- Make all efforts to provide a crew escape system for use during controlled gliding flight.
- Make every effort to increase the range of flight conditions under which an emergency runway landing can be successfully conducted in the event that two or three main engines fail early in ascent.

NASA IMPLEMENTATION OF RECOMMENDATION VII

LAUNCH ABORT

NASA is assessing the operational aspects of the launch phase and its associated abort modes. Launch abort mode definition and the associated ground and crew procedures, the range safety system, and the flight rules and launch commit criteria have been reviewed.

The modes of powered-flight abort were reviewed to ensure that procedures have been defined to maximize the flight conditions in which the crew can successfully achieve a runway landing or controlled escape, if an escape system is available.

The following abort modes exist during the launch phase: return to the launch site, transatlantic abort landing, abort once around, and abort to orbit. Abort boundaries for these conditions are defined for each mission and are a function of vehicle weight and performance. Figure 30 provides a schematic representation of these modes.

Each Shuttle flight has abort techniques to ensure that, if orbital insertion cannot be realized, a runway landing can be achieved. These techniques, which protect against the loss of major vehicle system capability or loss of a single Space Shuttle main engine (SSME), are called intact aborts. Each intact abort trajectory is carefully tailored to avoid exceeding the vehicle structural and thermal load capability as a result of the aerodynamic forces encountered during atmospheric flight.

The on-board computer contains software for both the three SSME normal trajectory profiles and the two SSME intact abort mode trajectory profiles. These profiles are evaluated for each launch to ensure that they are acceptable for the specific wind conditions measured on the day of launch.

The loss of two or three SSME's (contingency abort) has always been recognized as a potential event for any Shuttle launch, and manual piloting procedures were in place to cover these engine failure cases. The procedures were developed in the Shuttle mission simulator at the Johnson Space Center and were primarily designed to accommodate the pilot interfaces with the orbiter flight control system and on-board software.

The contingency abort modes were not initially subjected to the formal program certification process because they were not included in the program design requirements. As part of the return-to-flight process, an assessment of all aspects of contingency aborts, including crew procedures, has been initiated. Emphasis is being placed on the determination of vehicle structural integrity as it is exposed to the abort environments. Where structural concerns are indicated, changes to the procedures are being evaluated to determine their effectiveness in reducing the impacts. In those cases where piloting techniques are critical, with small tolerance for errors or deviations, automatic techniques are being evaluated for incorporation into the on-board software. The overall objective is to improve the probability of crew survival, either by achieving a runway landing at an abort site or by successfully flying the vehicle to within the conditions established for crew escape.

Shuttle launches from the Kennedy Space Center normally place the vehicle in one of two orbital inclinations: 28.5 degrees or 57 degrees. The ascent ground track profile for these typical launches is shown in Figure 31. Selected landing fields, as shown in the figure, are provided on the European and African continents for use in the event a transatlantic abort mode is required.

It is advantageous to have a landing site located near the ground track so that an abort landing can be achieved as quickly and safely as possible under minimum vehicle performance requirements. Dakar, Senegal, has provided this capability in the past for 28.5-degree launches; however, Dakar has some unfavorable topographic features and is not now considered to be acceptable as the "nominal" 28.5-degree landing site location. Several alternate locations along or near the ground track were assessed, and the landing field at Ben Guerir, Morocco, was selected as the prime 28.5-degree site. Equipment requirements for Ben Guerir have been identified and are being implemented to support the first flight.

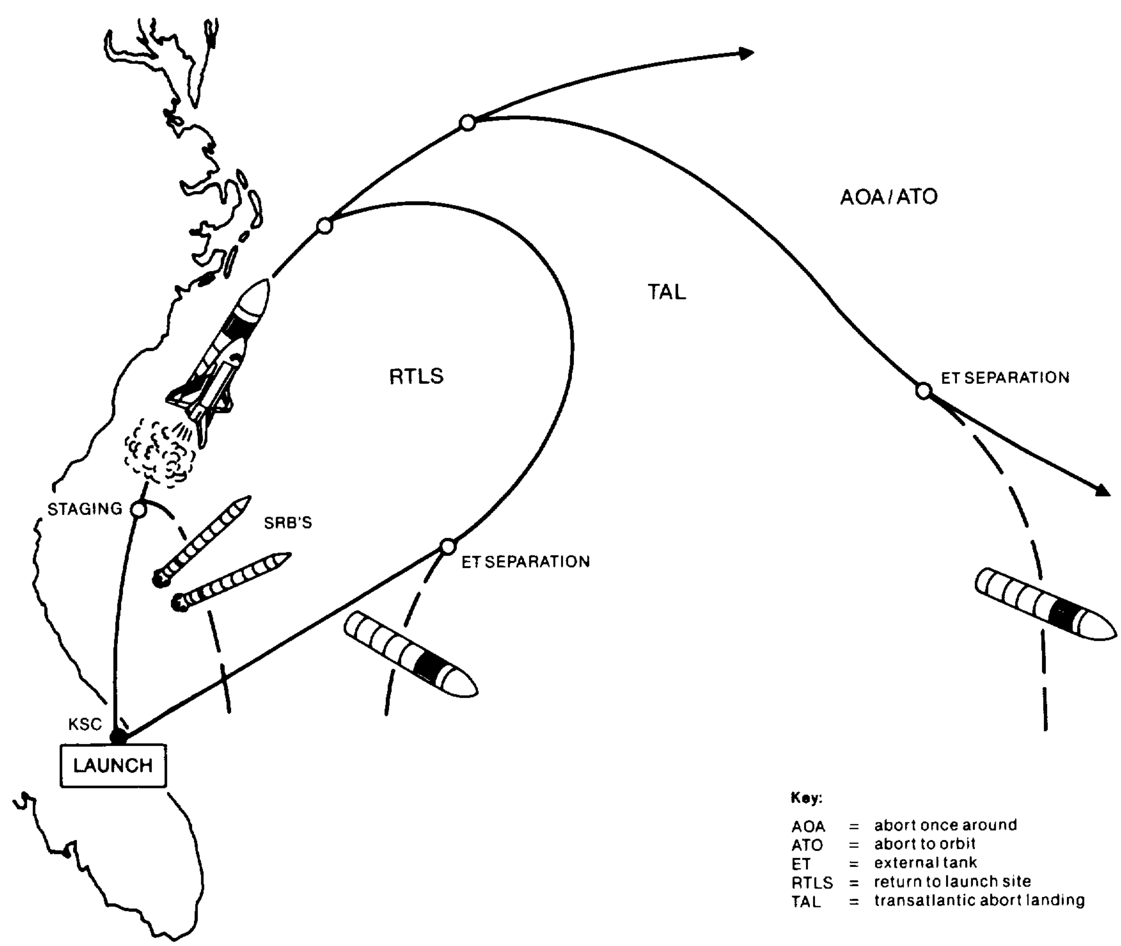
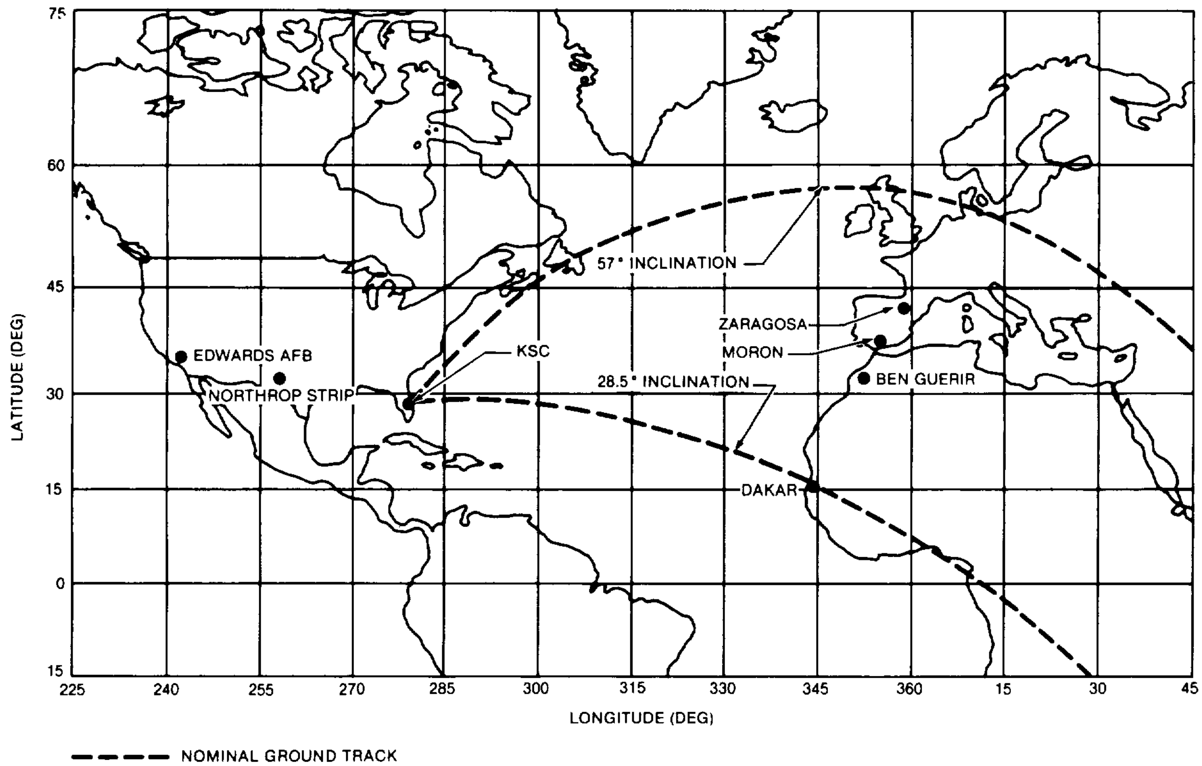


Figure 30. Space Shuttle Ascent Abort Modes



Abort Mode	Inclinations	
	28.5°	57°
Return to Launch Site	KSC	KSC
Transatlantic Abort Landing	Ben Guerir, Morocco Moron, Spain	Zaragosa/ Moron, Spain
Abort Once Around	Edwards AFB/Northrop Strip	Northrop Strip

Figure 31. Orbiter Abort Landing Sites

The weather support equipment and landing aids at all transatlantic landing sites are being augmented to increase the potential for landing safely in the event of an abort.

RANGE SAFETY SYSTEM

The Commission suggested that NASA and the Air Force critically reexamine the need for retaining a destruct package on the external tank. A review team composed of NASA, Air Force, and range safety personnel has reviewed the total range safety system, including the destruct package, and found that it will operate and perform as designed. The issue of whether the external tank portion of the system could, or should, be removed is being assessed, and a decision is expected in mid-1988.

The Naval Surface Weapons Center is participating in this review and performing analyses of potential solid rocket booster breakup scenarios to assess the probability of booster debris destroying the external tank.

Guidelines and procedures governing range safety tasks at the launch site and in flight have been reviewed. Several issues require further action and are receiving attention from both NASA and Air Force management. Joint approval of updated range safety documentation will be obtained before first flight.

DOCUMENTATION REVIEWS

Flight rules (which define the response to specific vehicle anomalies that might occur during flight) are being reviewed and updated. The Flight Rules Document is being reformatted to include both the technical and operational rationale for each rule. The review process is validating the performance limits set for each system and the data source for those limits.

Launch commit criteria (which define responses to specific vehicle and ground support system anomalies that might occur during launch countdown) are being reviewed and updated. These criteria are being modified to include the technical and operational rationale and to document any procedural work-arounds that would allow the countdown to proceed in the event one of the criteria was violated.

CREW ESCAPE

Although a final decision to implement a Space Shuttle crew escape system has not been made, the requirements for a capability to provide crew egress during controlled gliding flight have been established. Requirements for safe egress of up to eight crew members were determined through a review of vehicle escape routes, time lines, escape scenarios, and proposed orbiter modifications. The options for crew egress involve manual and powered extraction techniques. Design activities and wind tunnel studies have been initiated for each of these options.

Extraction techniques must ensure that the crew member does not contact the vehicle immediately after exiting the crew module. Several manual approaches being assessed for reducing the potential contact include a deployable tunnel that would provide sufficient initial velocity to preclude crew/vehicle contact and an extendable rod and/or rope that would place the crew release point in a safe region.

In the rod concept (Figure 32), the crew module hatch would be jettisoned and the rod would be extended through the hatch opening. The crew member would attach a lanyard to the rod, exit the vehicle in a tucked position, release at the end of the rod,

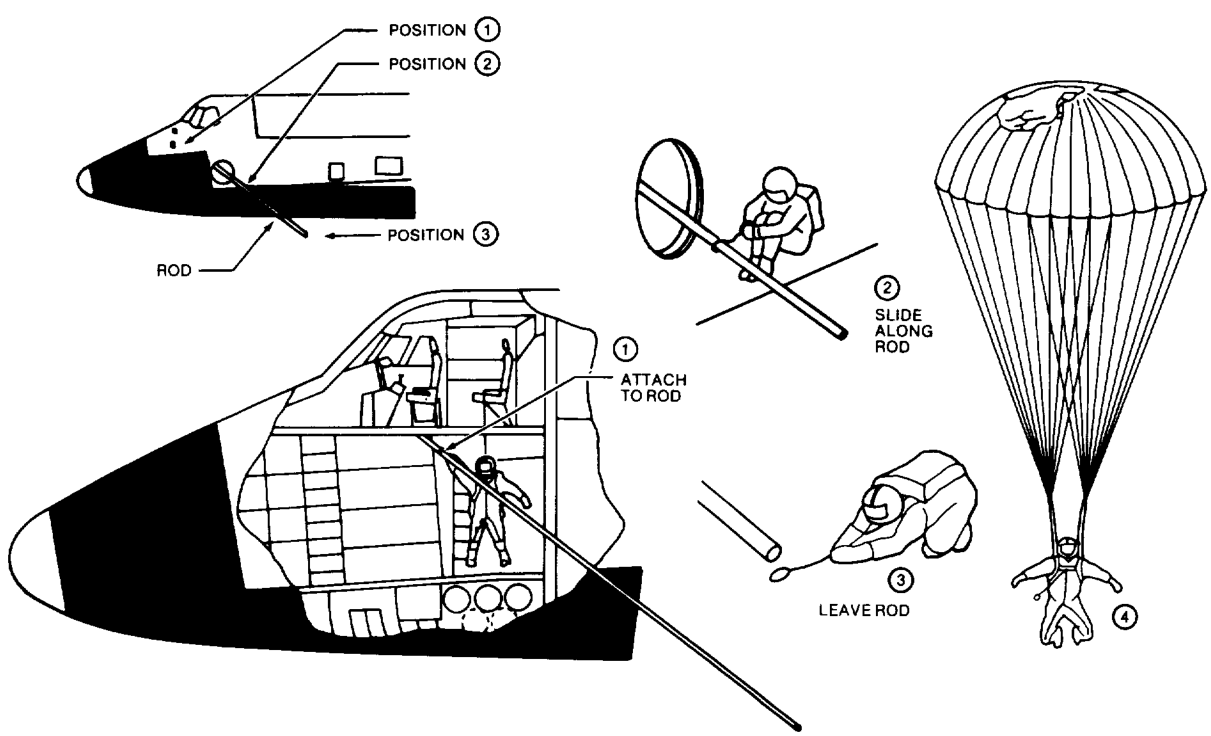


Figure 32. Extendable Rod Escape System

and parachute to a ground or water landing.

The powered extraction technique ensures that the crew will not contact the vehicle; however, it involves additional weight and crew compartment complexity and must be thoroughly evaluated to ensure that no safety hazards or additional risks would result from its implementation.

A study to determine the optimum powered extraction system for crew member egress was initiated in April 1986. This investigation included a review of possible escape routes and time lines, the effect of potential escape scenarios on the crew, and the weight and cost impact of required vehicle modifications. The study goal was to define a safe egress concept for up to eight crew members with minimal vehicle modification and weight penalties.

The study, completed in September 1986, considered ejection seats, tractor rocket extraction of seated crew members, bottom bail-out, and tractor rocket extraction through the side hatch. Each option considered the crew size, the required orbiter modifications, and the implementation schedule. These options are summarized in the following paragraphs.

An ejection seat concept that would extract up to five astronauts was assessed. During operation, this concept would jettison the tops of both the crew module and the forward fuselage before propelling the crew out of the opening in individual ejection seats. The addition of ejection seats would require major structural modification of the overhead consoles, flight deck floor, crew module structure, and forward fuselage structure.

A new ejection seat design would be required because the ejection seats used during the orbital flight test program are very large, and installation of five seats would affect orbiter aft flight deck payload station usage. The estimated first availability of the ejection seat concept is mid-1990. This concept is not being pursued because of late availability, extensive vehicle modifications, and crew size limitations.

Another extraction concept investigated was a tractor rocket system that would extract up to six seated crew members. Once activated, this system would jettison the tops of the crew module and forward fuselage and extract the crew using tractor rockets. This concept would require modification of the crew module and forward fuselage structure, the flight deck floor, and overhead consoles, and would affect payload station usage. The earliest availability of this modification is mid-1990. This configuration is no longer being pursued because of late availability, vehicle modification requirements, and crew size limitations.

A bottom bail-out concept that would provide safe egress for up to eight crew members was also assessed. In this concept, a panel would be opened on the bottom of the orbiter to deploy a guide chute, permitting the astronauts to exit the orbiter through the chute. This concept would require extensive structural modifications, including installation of a deployable panel and pyrotechnic devices to open the panel, design and installation of the chute, and relocation of some subsystem components. Modifications could potentially be completed and certified by 1989, but the concept is not being considered because of the highly complex vehicle changes required.

The final concept evaluated was escape through the side hatch using tractor rockets to propel the astronauts out of the orbiter. This method, which could safely extract up to eight astronauts, would require early venting of the crew module to equalize the crew module internal pressure with the external pressure. After venting is completed, the side hatch would be jettisoned. The crew members would then exit sequentially by using the tractor rockets. Required orbiter changes include addition of a cabin vent capability, modification of the side hatch structure to allow for hatch jettison, addition of pyrotechnic devices to jettison the hatch, and installation of the tractor rocket system.

While a decision to implement the system has not been made, development of the side hatch extraction capability for use in a crew egress/escape system (CEES) has been authorized by the Director, NSTS. The system consists of a jettisonable crew hatch (also applicable to the manual bail-out mode), individual rockets to safely extract the crew from the vehicle, and personnel survival equipment. The crew escape sequence (Figure 33) would be initiated by venting the crew module to ensure that no pressure differential exists prior to hatch jettison. The side hatch would then be pyrotechnically jettisoned at approximately 22,000 feet (Figure 34). Crew escape would be initiated during controlled gliding flight at an altitude of 20,000 feet and a velocity of 200 miles per hour.

After the hatch is jettisoned, the crew moves to the hatch area and climbs onto a guide ramp. Each crew member attaches a tractor rocket pendant to their parachute/survival pack. The crew member then activates the tractor rocket, and is extracted from the orbiter (Figure 35). Each crew member repeats this procedure until the commander exits at an altitude of approximately 10,000 feet. Minimum desirable ejection altitude is 5,000 feet.

Once the hatch is jettisoned, a crew of eight could nominally egress in less than 2 minutes. Each parachute/survival pack would include a parachute canopy, activated automatically at a predetermined altitude, a

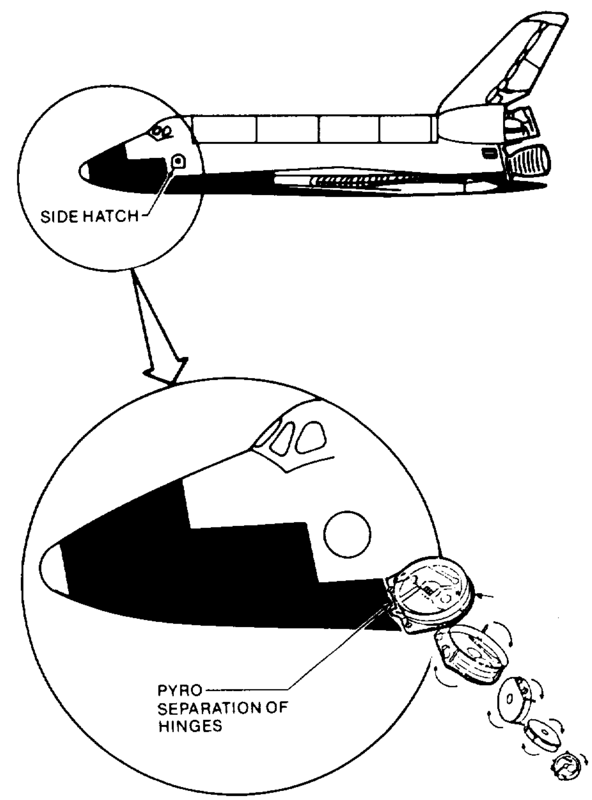


Figure 34. Side Hatch Jettison for Crew Escape

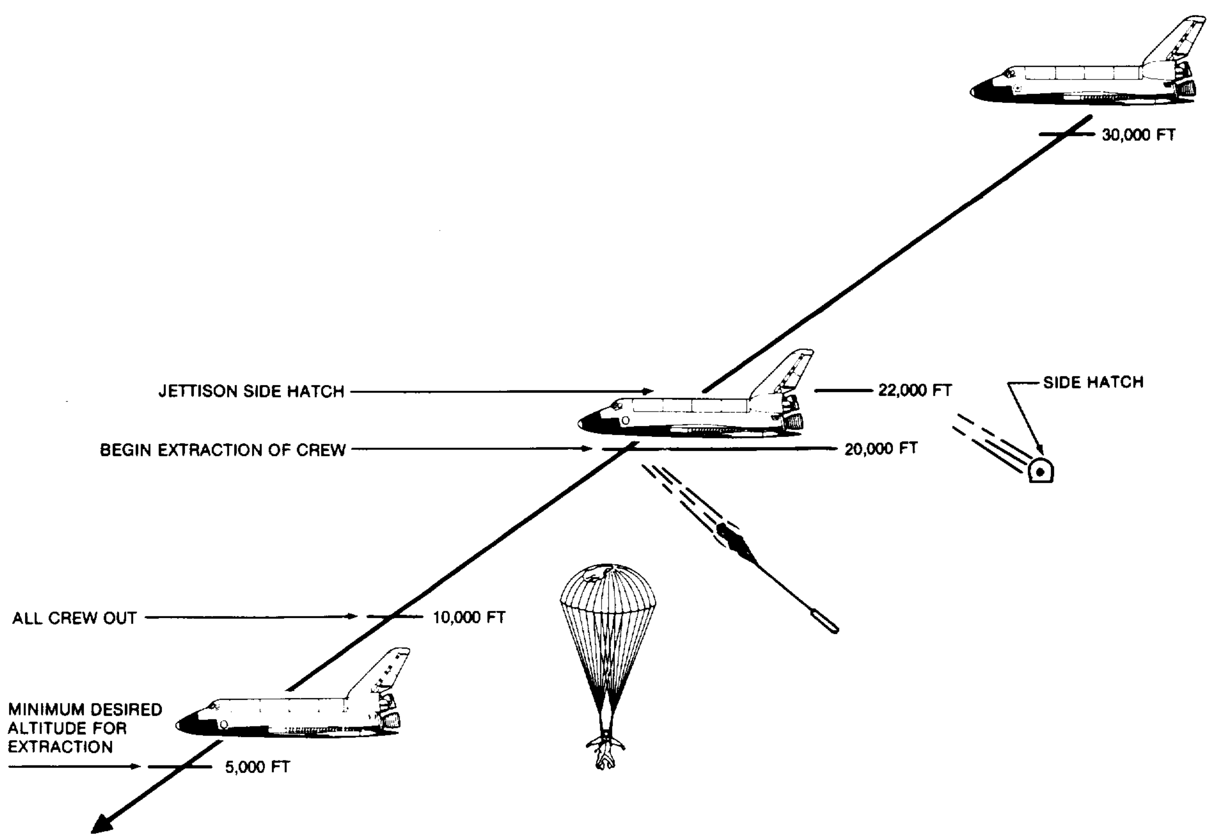


Figure 33. Crew Egress/Escape System

life raft, and other equipment required for survival while awaiting rescue.

System certification of the CEES will be based on component testing, full-scale integrated system tests, wind tunnel tests, and aircraft flight tests. Full-scale integrated system tests will be conducted combining all components of the newly designed equipment. Several tests will be performed to verify that the entire integrated system functions properly.

Aircraft tests are planned to verify design analysis and the operation of the tractor rockets during simulated flight conditions. During these tests, anthropomorphic dummies will be extracted from the side of an airplane modified to represent the orbiter configuration.

Although the decision on whether to incorporate the CEES, pursue one of the manual escape modes, or continue development of other approaches has not been made, the jettisonable hatch modification has been approved and will be installed prior to the first flight.

FIRST-STAGE-BOOST ESCAPE SYSTEM

A study to evaluate the feasibility of a future escape system to potentially enhance crew survival during first-stage flight (solid rocket boosters thrusting) has been initiated. Study objectives include determination of system cues required to indicate the need for escape, methods of escape initiation, and escape system design.

In support of this study, NASA has requested that the Naval Air Development Center lead a team of industry and Government escape system engineers in performing a detailed study of ejection seat concepts to determine the feasibility of using them in the Shuttle. NASA's Langley Research Center is performing a similar study of a system to pro-

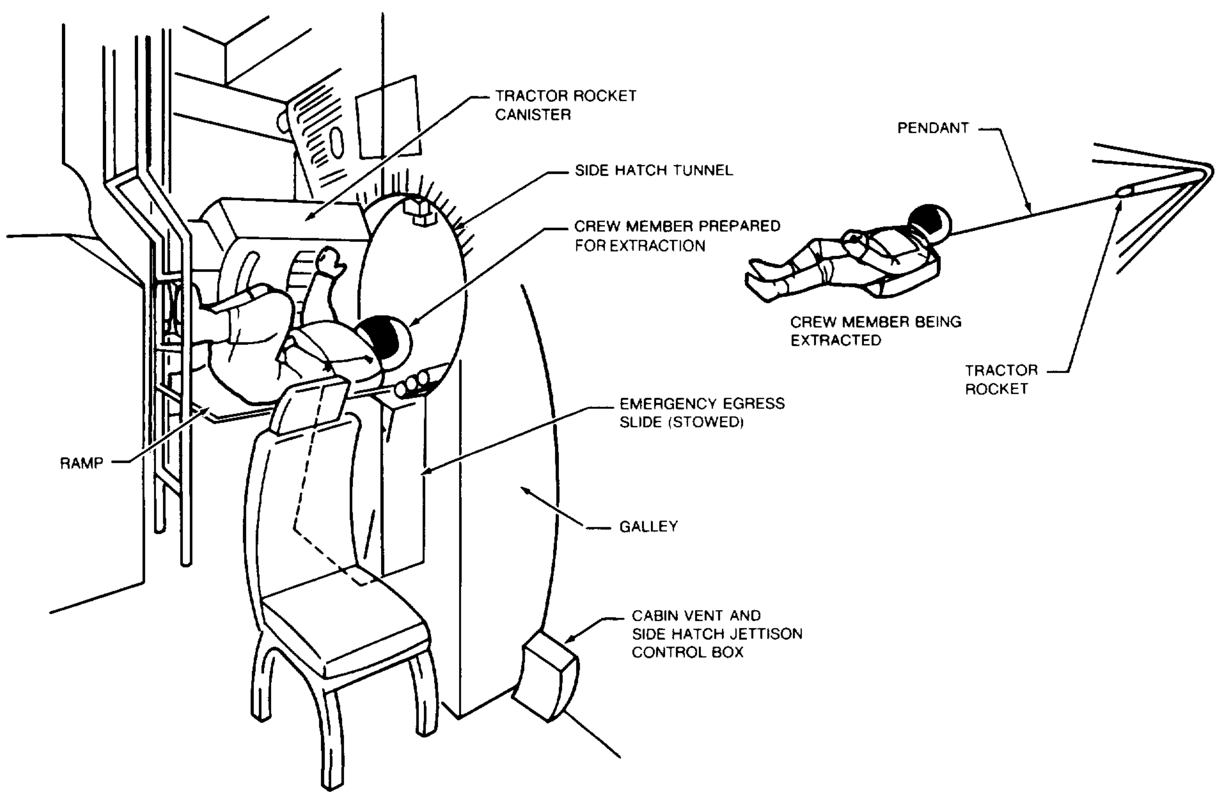


Figure 35. Tractor Rocket Crew Escape System

vide rocket extraction capability from seated positions.

GROUND EGRESS

Emergency egress procedures for both crew and support personnel during the prelaunch period and after orbiter landing are being investigated. This assessment includes the hazards present during prelaunch and landing operations, the various systems for detecting the hazards, and possible egress routes.

A number of areas in the emergency egress capability that require improvement or further testing or evaluation have been identified. An emergency egress rescue working group has been chartered to resolve these issues.

A prelaunch pad egress simulation was conducted at the Kennedy Space Center in November 1986. In the test, an orbiter closeout and rescue crew conducted an end-to-end emergency egress with flight crew participation. Action items resulting from this exercise are being resolved. Another series of tests, to simulate postlanding egress, was conducted in April 1987, and a night pad egress exercise was successfully completed in June 1987. The results of both are being evaluated.

The large number of actions generated by these tests indicated that some of the existing equipment and procedures did not have adequate redundancy or simplicity for emergency use. Major modifications to the launch pad have been recommended, including a flame protection barrier for the access arm and launch pad structure, additional crew slide wire systems, and a new crew bunker. Other changes being considered include items such as improved armored personnel carriers for crew evacuation, new emergency breathing equipment, additional emergency lighting, and upgraded crew training.

Modifications to the launch pad and landing emergency equipment will be retested in end-to-end simulations for flight readiness certification. Periodic retesting will continue as a permanent part of the training and qualification process for launch and landing operations support personnel.

An egress slide (Figure 36) that can be used for emergency escape after landing is included in the CEES hardware development activity. This slide, which is similar to those used in commercial aircraft, will provide quick and safe egress for all members of the crew. In an emergency situation where the side hatch cannot be readily opened on the ground, the hatch can be jettisoned and the slide activated by the crew. The slide can also be used in a postlanding emergency, when the hatch can be opened but standard ground egress equipment is not available.

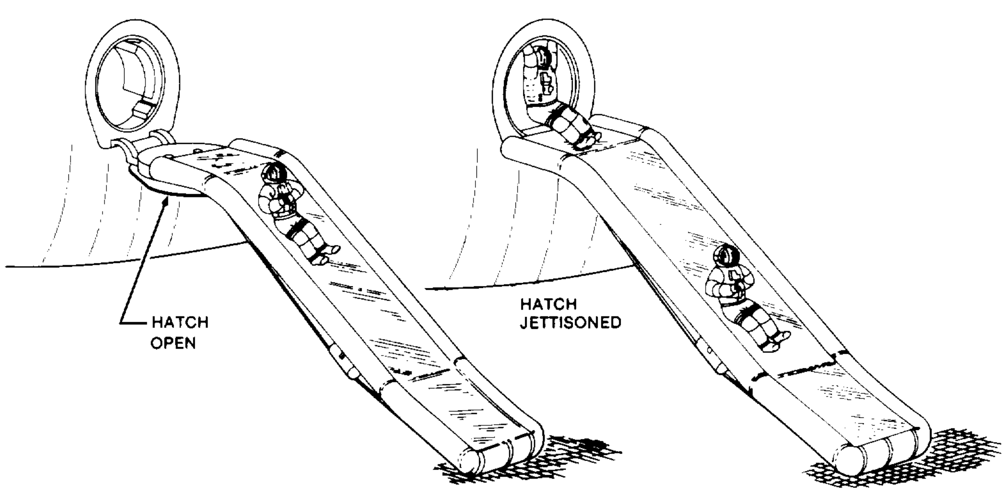


Figure 36. Crew Egress Slide Deployment

Recommendation VIII

Presidential Commission Recommendation VIII

Flight Rate. The nation's reliance on the Shuttle as its principal space launch capability created a relentless pressure on NASA to increase the flight rate. Such reliance on a single launch capability should be avoided in the future.

NASA must establish a flight rate that is consistent with its resources. A firm payload assignment policy should be established. The policy should include rigorous controls on cargo manifest changes to limit the pressures such changes exert on schedules and crew training.

NASA IMPLEMENTATION OF RECOMMENDATION VIII

FLIGHT RATE REQUIREMENTS

Several major actions taken in the last year have reduced the overall requirements for NSTS launches. Each of these actions reduces the reliance on the Space Shuttle as this nation's single launch capability and maximizes its availability for missions that require the unique capability of the vehicle and its crew.

The addition of a fourth orbiter to the fleet will significantly improve the current program launch capability. However, a reduction in NSTS requirements must be achieved to ensure a launch rate consistent with the available resources.

NASA and the Department of Defense (DOD) have jointly established, and are implementing, a mixed-fleet concept of expendable launch vehicles (ELV's) and the Shuttle to meet national requirements for access to space. Many of the DOD payloads previously scheduled on the NSTS can be launched on ELV's. NASA and DOD have identified these payloads and replanned the overall launch strategy to provide for their launches on ELV's.

The initial step in this effort resulted in the identification of requirements for more than twice the number of Titan IV launch vehicles (10 to 23) planned for DOD payloads in the near term (through 1992). The Shuttle and the Titan IV are nearly equivalent in launch capability; therefore each additional Titan IV launch reduces the DOD requirements for NSTS launches by one flight.

The medium launch vehicle (MLV) being developed by DOD will be used to launch Navstar Global Positioning System satellites. Some 20 of these DOD satellites, previously scheduled for deployment from the NSTS, are now planned for the MLV. As part of the budget and manifest planning exercises currently under way, NASA and DOD are evaluating options for additional offloading of payloads from the Shuttle to ELV's.

The presidential decision to limit use of the NSTS for launch of communication satellites to those with national security or foreign policy implications has resulted in more than 20 of these satellites, previously scheduled on the NSTS, being reassigned to commercial ELV's. NASA has worked actively with the United States commercial ELV industry and the commercial satellite owners and operators to ensure an orderly transition.

The NASA Office of Space Flight conducted a study to determine the civil payload launch requirements that could be satisfied with a mixed fleet. This study concluded that approximately 25 percent of the NASA and National Oceanic and Atmospheric Administration payloads currently scheduled for launch on the NSTS could potentially be launched on ELV's.

NASA has initiated the overall planning required to implement a mixed fleet, to define the required near- and far-term launch requirements, and to identify the number, type, and cost of the launch vehicles required to satisfy the requirements.

For payloads in the post-1992 time period, the mixed-fleet study recommended further Shuttle offloading through the use of an unmanned Shuttle-derived vehicle (SDV). NASA is vigorously exploring SDV concepts as a means of satisfying future payload requirements.

FLIGHT RATE CONSISTENT WITH RESOURCES

In March 1986, Admiral Truly directed that a "bottoms-up" Shuttle flight rate capability assessment be conducted. To accomplish this, a Flight Rate Capability Working Group was established. Representatives from each NSTS Program element that affects the flight rate participated in the group.

Ground rules were developed to ensure that projected flight rates were realistic. These ground rules addressed such items as overall staffing of the launch process work

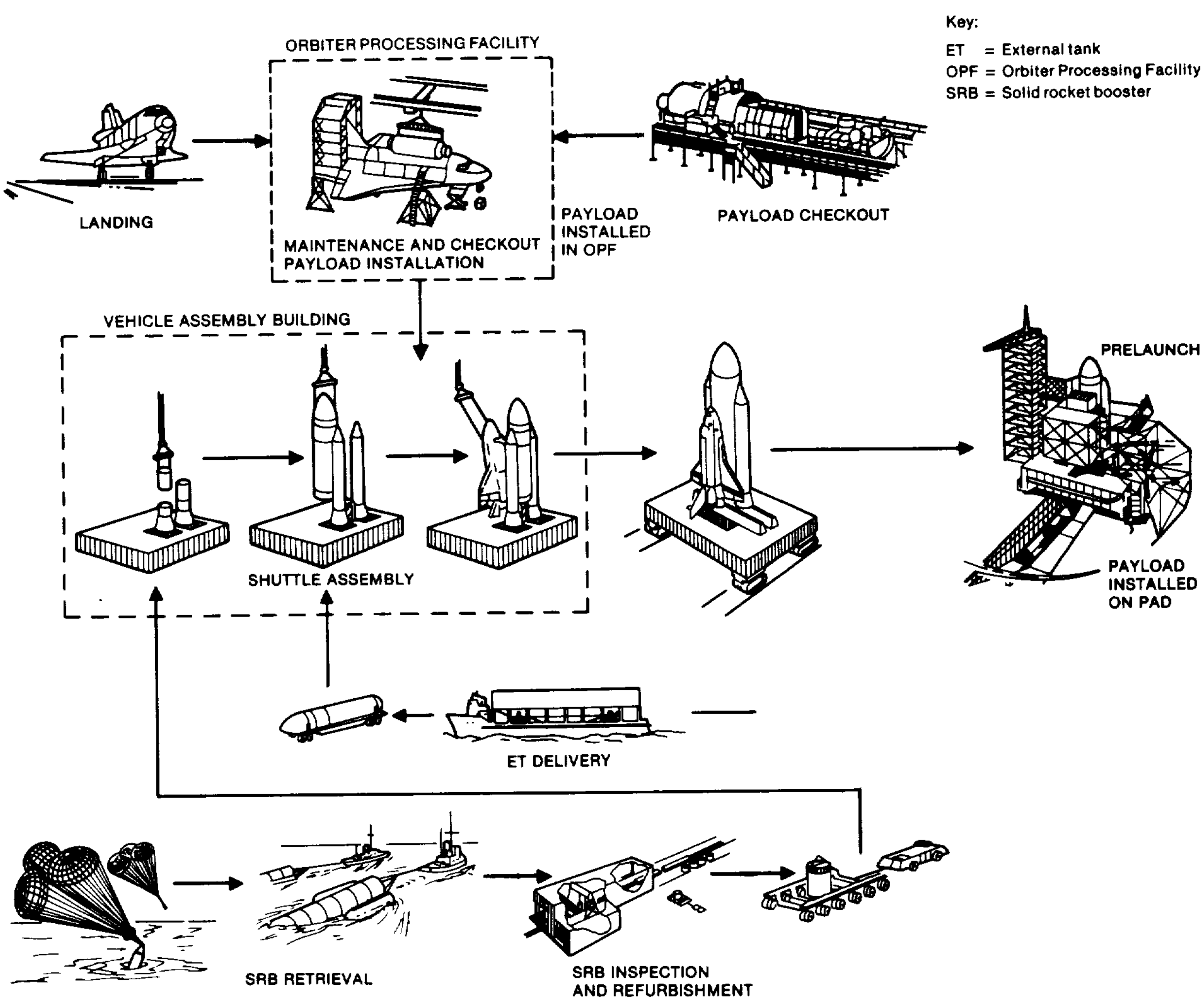


Figure 37. KSC Space Shuttle Ground Operations

force, work shifting, overtime, astronaut training, and maintenance/inspection requirements for the orbiter, main engine, solid rocket motor, and other critical systems.

Based on these ground rules, a careful assessment was made of the vehicle processing cycle (Figure 37), the payload preparation process (Figure 38), and the mission planning process (Figure 39) to determine their capacity to support the flight rate. The actual flight rate that can be achieved at any time is dependent on a well-defined and stable set of requirements that allow all the activities portrayed in these figures to be accomplished on a carefully planned basis.

The working group identified enhancements required for the Shuttle mission simulator, the Mission Control Center, the Orbiter Processing Facility, and other areas such as training aircraft and provisioning of spares. With these enhancements and the replacement orbiter, NASA projects a maximum capability of 14 flights per year (Figure 40). This capacity, considering lead time constraints, learning curves, and budget limitations, is expected to be achieved by 1994. The experience gained after flights are resumed will be used to adjust future flight rate projections.

Two independent assessments of Shuttle flight rate capability have been made. A National Research Council (NRC) report published in October states in part:

> "Three Orbiters can sustain a rate of 8 to 10 flights per year after an initial buildup period of approximately 2 years providing: (1) no Orbiter is lost or becomes inoperable, (2) adequate logistics support exists, and (3) no problems exist that require extensive downtime. A surge rate of 12 flights per year should be possible

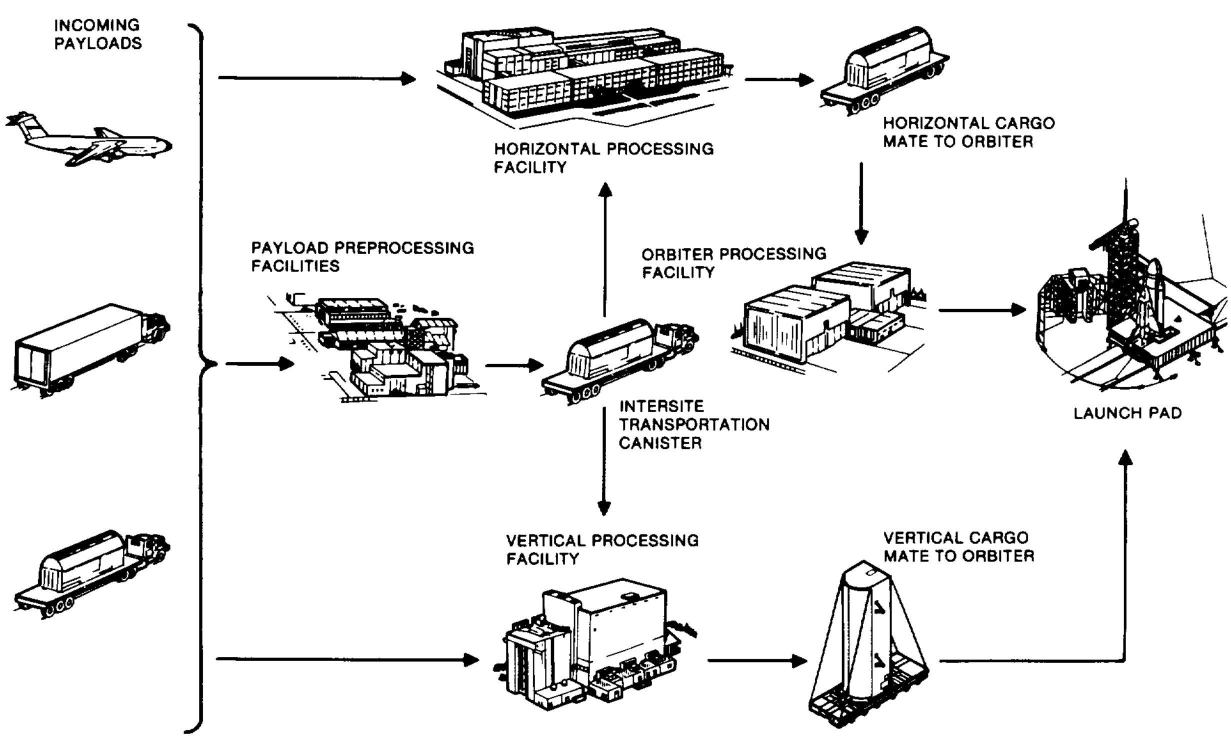


Figure 38. KSC Space Shuttle Payload Operations

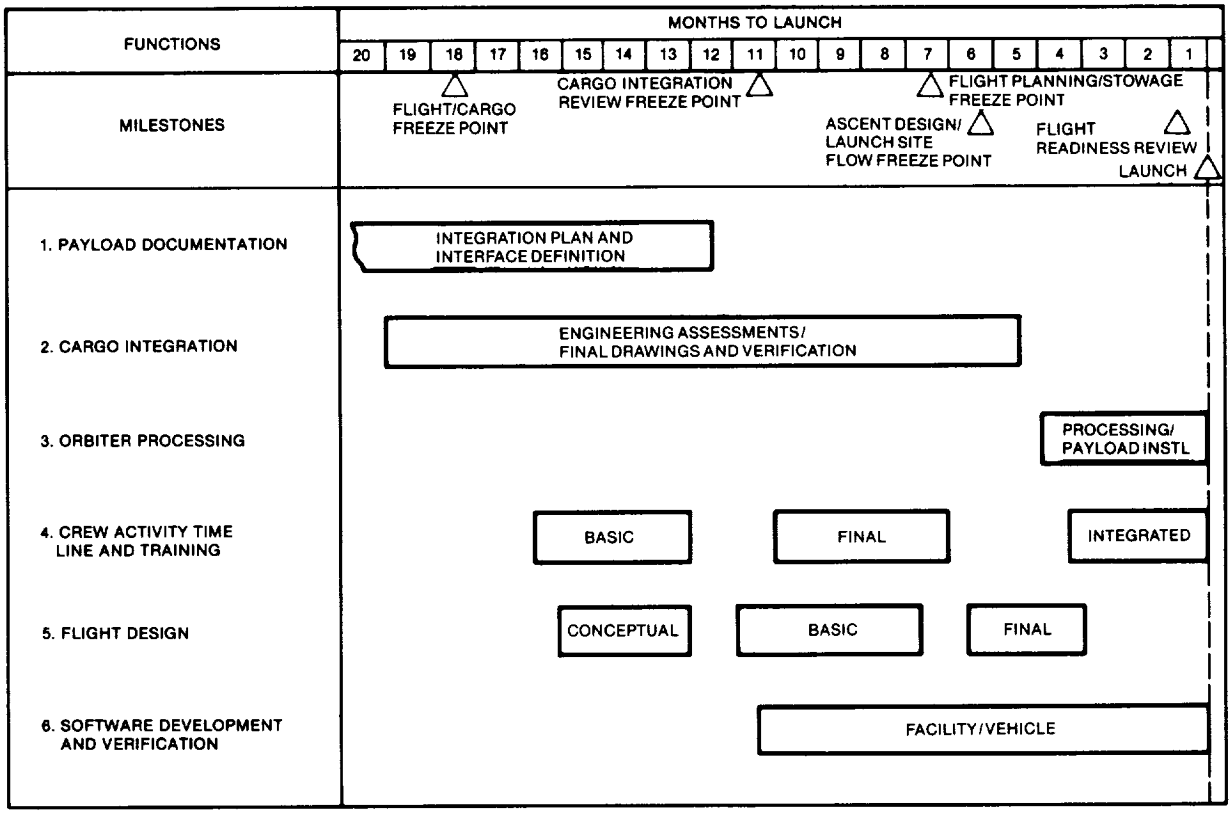


Figure 39. Mission Planning Time Line

for short periods of time for simple payloads and flight plans.

"With a 4-Orbiter fleet the sustainable flight rate would be 11-13 per year with a surge rate of 15 flights per year only if appropriate ground support facilities are acquired.

"In order to sustain such rates and take account of possible contingencies, the Shuttle scheduling should be based upon fewer vehicles than are actually in the inventory by almost one Orbiter."

The other independent assessment was made by the Aerospace Safety Advisory Panel. At the conclusion of their study, the panel concurred with the NRC report. Since these assessments are in close agreement with the NASA assessment, it is felt that the capability projections are realistic.

MANIFESTING POLICY AND RIGOROUS CONTROLS

The manifesting and scheduling of payloads on the NSTS will be consistent with the flight rate projections defined above.

To ensure the stability of future cargo manifests, firm policies have been established and a formal control process has been implemented. The control process provides for a series of "freeze points" (Figure 39), at specified intervals over the year and a half required to prepare for each flight, that rigidly define the vehicle, payload, and mission characteristics.

Approximately 18 months before launch, the flight production process begins with a flight/cargo freeze point that baselines the primary payload assignments and defines the orbiter vehicle configuration. Only manda-

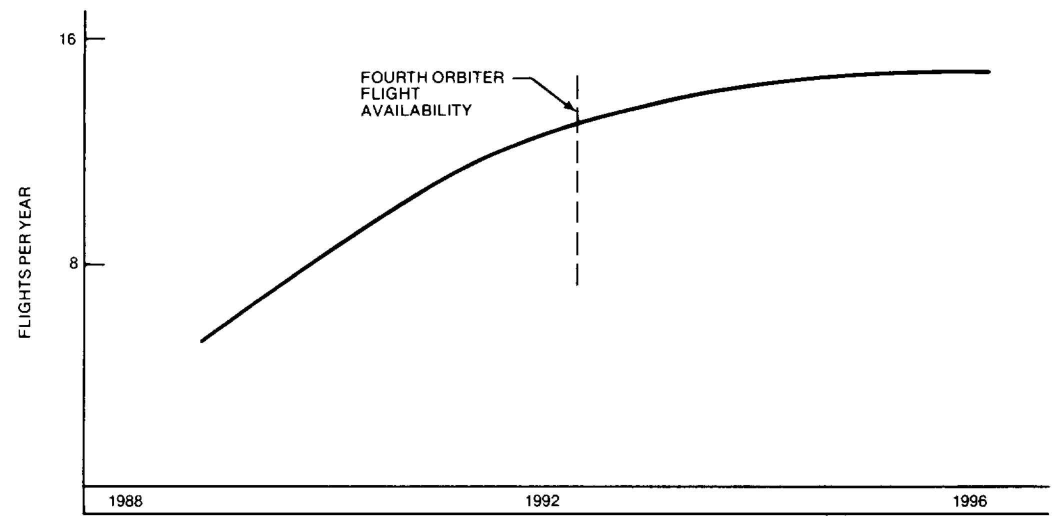


Figure 40. Projected Flight Rate Capability

tory changes required to ensure crew or vehicle safety, or the accomplishment of primary mission objectives, will be made after this point.

Eleven months before launch, the cargo integration freeze point baselines the detailed flight design, orbiter hardware and software, payload specialists assignments, if any, and secondary payloads.

At 7 months, the flight planning and stowage freeze point baselines crew activities and crew compartment stowage. This is the last opportunity to add orbiter mid deck or small payload bay self-contained payloads that meet standard NSTS interface requirements. One month later, the ascent flight design-launch site flow review freeze point baselines the ascent trajectory and the launch site work plan.

This freeze point process is conducted under the rigorous rules of the NSTS change control process. This ensures that changes receive the proper senior program management review and are acceptable in terms of their effect on crew training, work schedules, and other elements that could adversely impact mission safety.

Other facts that strengthen manifest stability include:

- Removal of the NSTS from competition with commercially available launch services has substantially relieved the pressure of payload demands that precipitated many of the late manifest changes that occurred on the previous flights.
- NASA policy regarding the role of payload specialists is presently under high-level management review. Although the completion of this review is scheduled for late 1987, firm decisions already made ensure that adequate time will be available to incorporate the payload specialist activities into the mission plans and to properly train the crew.
- The presently approved planetary missions will be launched on the NSTS. The threat of the increase in program costs and loss of science that result from delay of one of these missions puts a heavy stress on the system, not only on the planetary launch itself but also on the preceding missions. To avoid the potential launch pressure from two planetary missions in sequence, NASA has established manifesting rules that prohibit the scheduling of consecutive missions with fixed launch periods. New planetary mis-

sions will be strong candidates for launch by unmanned launch vehicles.

The actions discussed above are being implemented, and the flight rate is now set at an achievable level, consistent with program resources, the four-orbiter fleet, and an agency-wide commitment to safety. With the mixed-fleet policy, many payloads have been reassigned to other launch vehicles. Firm manifesting policies have been established, and rigorous change control procedures have been implemented. Any required manifest change that is not consistent with these defined policies will cause that payload to be scheduled on a later mission. The resumption of flight is approached with confidence that these measures will prove effective.

Recommendation IX

Presidential Commission Recommendation IX

Maintenance Safeguards. Installation, test, and maintenance procedures must be especially rigorous for Space Shuttle items designated Criticality 1. NASA should establish a system of analyzing and reporting performance trends of such items.

Maintenance procedures for such items should be specified in the Critical Items List, especially for those such as the liquid-fueled main engines, which require unstinting maintenance and overhaul.

With regard to the Orbiters, NASA should:

- Develop and execute a comprehensive maintenance inspection plan.
- Perform periodic structural inspections when scheduled and not permit them to be waived.
- Restore and support the maintenance and spare parts programs, and stop the practice of removing parts from one Orbiter to supply another.

NASA IMPLEMENTATION OF RECOMMENDATION IX

NASA has developed an improved integrity assurance program to ensure that the performance of all systems meets the design requirements for each flight.

System integrity assurance includes those configuration, inspection, maintenance, operations, and analysis activities, beginning with initial hardware acceptance tests and continuing through the life of the hardware, that are required to ensure safe and reliable operation of the NSTS. These activities are performed at the launch and landing sites, the design centers, element contractor facilities, off-line repair and maintenance facilities, and during flight operations. Information management systems that provide the appropriate visibility into these activities are part of the overall program.

Development of this capability is being complemented by a program-wide documentation review to rebaseline the NSTS processing requirements and procedures.

MAINTENANCE SAFEGUARDS

NASA has developed and published the System Integrity Assurance Program (SIAP) Plan to ensure that the NSTS Program is supported by an integrated maintenance and logistics program. The SIAP establishes the functional responsibilities and program requirements necessary to provide the proper configuration, operations, inspection, maintenance, logistics, and certified personnel to ensure that the NSTS is ready for flight.

The SIAP includes a management information system that provides the necessary insight into requirements verification, problems, anomalies, and performance trends to verify the status of readiness for the next flight. The Deputy Director, NSTS Program, is responsible for ensuring implementation of the SIAP Plan.

The program compliance assurance and status system (PCASS), a relational data base and reporting system that provides the capability for data and problem communications and control across the program, is the key element of the SIAP. It compiles data from the project elements and provides NSTS management with visibility and access into program critical data, including requirements status, problem data, trends, risk decisions, hazards, critical item history, and failure modes and effects analysis/critical item data. This system provides the information required by the safety, reliability, maintainability, and quality assurance (SRM&QA) organization to perform analysis and report data independently of the NSTS. Figure 41 reflects the major capabilities of the SIAP. The major elements of the PCASS are indicated in Figure 42.

Specific tasks and responsibilities for establishing format and data requirements have been identified for the NSTS Program and each project element, and are being implemented. These data will be collected and reported, using systems currently in place, until the system software can be fully developed. Data acquired will be used to verify that all configurations, operations, and maintenance requirements, structural inspections, problems, or actions have been closed out, or waivers have been written prior to each flight.

The PCASS will provide visibility into the status of mission flow, flight hardware schedules, operational maintenance requirements, and launch constraints, and provide status, assessment results, and closure rationale for Criticality 1 and 1R hardware and software anomalies.

All anomalies occurring during flight vehicle prelaunch processing, flight, and turnaround and maintenance will be incorporated into the data base, as will anomalies occurring in the Shuttle mission simulator, Shuttle Avionics Integration Laboratory, and off-line maintenance facilities. The data repository provides the capability to correlate actual failures with predicted failures and to generate critical item status and history reports.

A risk decision history data base will be included in the system and will be used to assist program management in reviewing deferral actions, waivers, and exceptions. Trend analysis algorithms will be used to perform reliability, performance, and supportability trends and will form the basis for modifying requirements, procedures, and/or spares inventories.

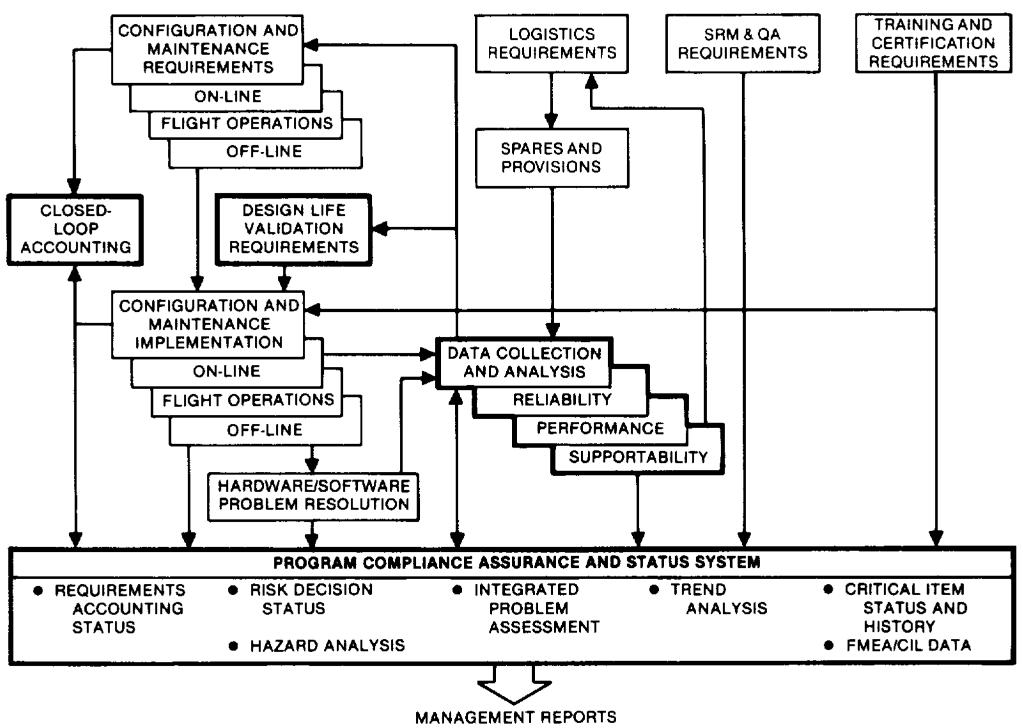


Figure 41. System Integrity Assurance Program

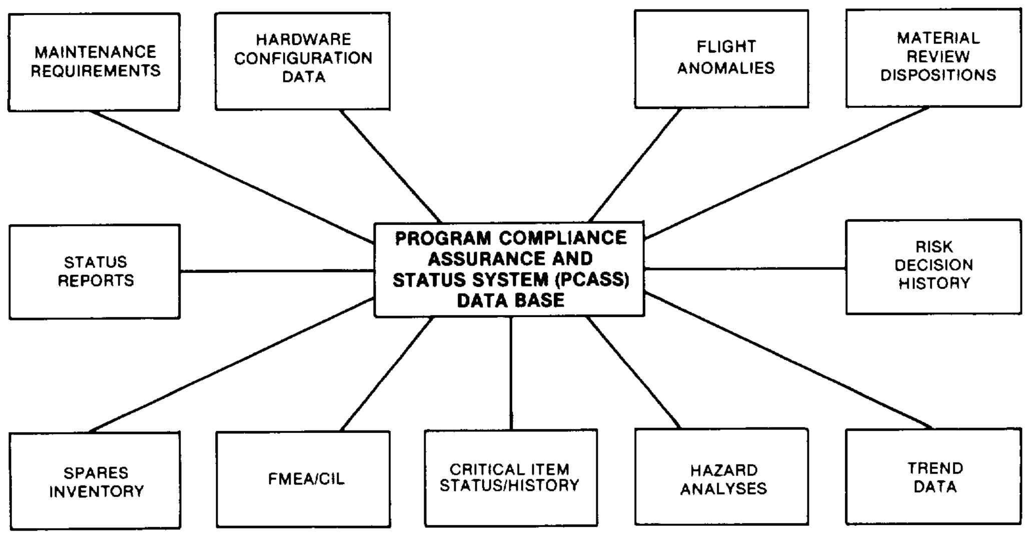


Figure 42. PCASS Data Base Elements

ANALYSIS AND REPORTING

The SRM&QA organization will use the PCASS data to:

- Support independent safety assessments of hardware and software that perform Criticality 1 and 1R functions
- Review and update failure modes and effects analysis (FMEA)/Critical Items List (CIL)/hazard analysis (HA)
- Establish mandatory quality acceptance criteria for work performed on the vehicles
- Identify repetitive failures for management visibility and action
- Develop reliability trends and projections

SRM&QA is responsible for implementing an independent problem reporting and corrective action system for the NSTS Program. The element projects are responsible for providing the data for this system. Utilizing the data compiled by the projects, SRM&QA will monitor the performance of, and perform trend analyses on, selected Criticality 1, 1R, and 2 components.

The NSTS will utilize the PCASS and the problem reporting and corrective action system to analyze the performance of all element hardware and software systems. This analysis will be performed at the system line replaceable unit (LRU) level. Specific "performance change" criteria will be defined which, when exceeded, will result in a detailed review of the affected LRU or system. Performance trend data will be used to extend the design life of the LRU's, when the data indicate such an extension is justified. Adverse performance trends will be used to define a reduced design life validation program.

Performance trend data collection requirements will be defined, and the data collected will be analyzed and used to update such factors as turnaround time, mean time between failures/repairs, and maintenance demand rates. Equipment supportability trend data will be used for establishing logistics requirements, which will ensure that adequate spares and provisions are available to support the projected flight rate. Time/age/cycle requirements developed from data compiled through the PCASS will be incorporated into the appropriate maintenance and operational documentation.

A design life validation program is being developed which will verify that critical LRU's and systems meet their certified design life requirements. Factors such as time/age/

life cycle, degradation/wear, and performance comparisons with original acceptance test results will be considered in selecting components for teardown analysis. Results of the teardown analyses will be integrated into the processing requirements, design life certification, time/age/cycle limits, logistics requirements, FMEA/CIL's, and hazard analyses, as appropriate.

SPARES AND MAINTENANCE

A prime objective of the SIAP is to ensure a strong logistics (spares) and maintenance function. Logistics support plans are being reviewed, updated, and implemented by the element projects in accordance with requirements contained in the SIAP. These plans will identify the requirements for spares and provisions necessary for supporting flight-to-flight reconfiguration, maintenance operations, and replacement of failed and limited-life LRU's, to preclude the need for using LRU's from other flight vehicle or ground systems.

NASA has alleviated the requirement for routine removal of parts from one vehicle to supply another by expanding and accelerating various aspects of the NSTS logistics program. The SIAP defines the ground rules for such removal of parts, which will be permitted only when approved by the Program Requirements Control Board.

An improved hardware inventory management system is being implemented to track hardware availability and inventory requirements. Spares and repair forecasting techniques are being updated using projected flight rate and trend analysis data. Spares and provisioning requirements to support replacement of failed or limited-life hardware are being addressed.

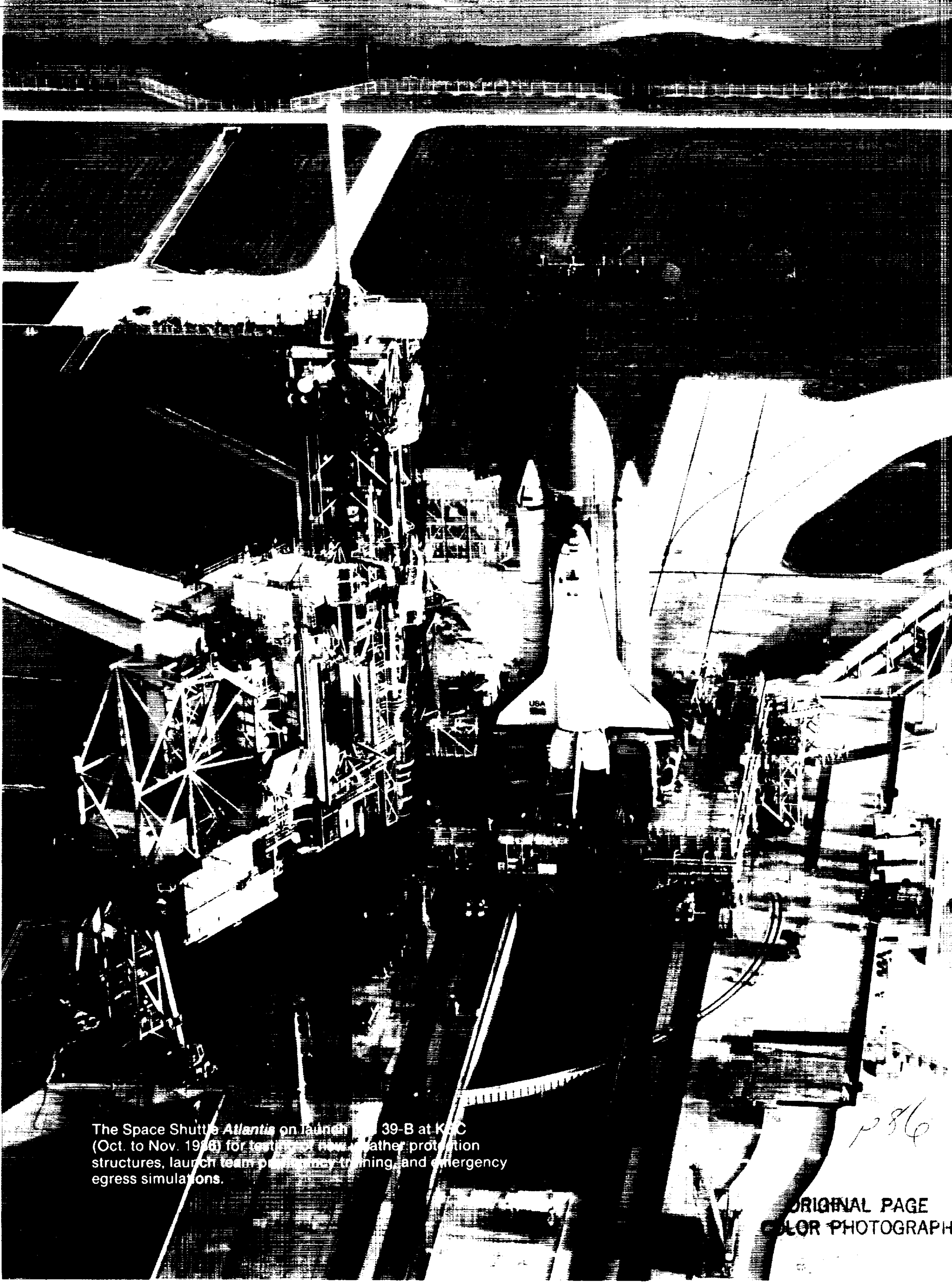
Additional repair capability is being developed for the Shuttle Services Center to ensure that flight and critical ground hardware can be repaired and maintained within design specification requirements in a timely manner. The center provides the capability to perform local test and repair of components and reduces the need for sending items back to the original equipment manufacturer for repair. Hardware status will be maintained through modification/repair cycles, and data will be recorded to support trend analysis.

DOCUMENTATION REVIEWS

Program-wide reviews of the vehicle processing requirements and implementation documents are under way, and are discussed in Part 2 of this report. This review and revision of existing maintenance documentation by each NSTS project has resulted in the identification of new maintenance and inspection requirements, which are being incorporated into the appropriate documentation after review and approval. The operational maintenance instructions are being modified to ensure that all procedures which involve Criticality 1 and 1R items are prominently displayed. These documents must be approved by the appropriate NASA design center prior to use. Any changes that affect critical items or critical processes must receive appropriate design center concurrence.

PART 2

RELATED RETURN-TO-FLIGHT ACTIONS



The Space Shuttle *Atlantis* on launch pad 39-B at KSC (Oct. to Nov. 1986) for testing of new weather protection structures, launch team proficiency training, and emergency egress simulations.

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RELATED RETURN-TO-FLIGHT ACTIONS

Several activities are under way or planned to support the safe return to flight that are not directly related to the Commission recommendations. These include:

- The program requirements for flight and ground system hardware and software are being updated to provide a clear definition of the criteria that the project element designs must satisfy.
- The NSTS system designs have been reviewed, and items requiring modification prior to flight have been identified.
- Existing and modified hardware and software designs are being verified to ensure that they are compliant with the design requirements.
- The program and project documentation, which implements the redefined program requirements, is being reviewed and updated.
- Major testing, training, and launch preparation activities are continuing or are being planned.

MAJOR REVIEWS

Design Requirements Review (DRR)

The DRR process, begun in the spring of 1986, is a programmatic review of NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification, and the Shuttle Interface Control Documents (ICD's).

Volume X identifies the basic requirements that the element hardware must be designed and certified to meet. The ICD's define the electrical, fluid, and mechanical interfaces between the elements and between the elements and the ground support systems.

Reviews are being conducted by each element contractor, the system integration contractor, and NASA. Proposed changes to amplify, add, or delete requirements are being presented to the element projects to establish a recommended list of changes. The list is reviewed by the NSTS Engineering Integration Office for resolution of the change recommendations. Changes approved by this office are submitted to the Program Requirements Control Board (PRCB) for approval.

When complete, the DRR process will provide the NSTS Program with improved, updated documentation of the design requirements and will ensure that each project element has a clear understanding of the criteria that its design must satisfy.

System Design Review (SDR)

The NSTS Program initiated the SDR process to ensure review of all concerns related to hardware and software performance in the mission environment and to identify items requiring redesign, analysis, or test prior to flight. Each organizational element of the program participated in this process. SDR items originated from design or test issues, prelaunch operations experience, in-flight operations or anomalies, postflight inspection or analyses, and other design or operations assessments. The review included a thorough description of the system issue, its potential consequences, recommended corrective action, and alternatives. Three categories were established to prioritize the changes:

- **Category 1.** Changes/studies required prior to the next flight because the current design may not contain a sufficient safety margin.
- **Category 2.** Changes/studies not required before the next flight but which should be implemented in the near term to increase the safety margin.
- **Category 3.** Changes/studies required to enhance vehicle safety, performance, or operations. These items consist of modifications and studies that can be approved in the normal project and program control boards and implemented under normal program schedules.

The failure modes and effects analysis (FMEA)/Critical Items List (CIL) reviews of flight hardware, software, and ground support equipment also identified items requiring redesign, analysis, and/or testing before first flight. The major system changes for each element project that resulted from the SDR and the FMEA/CIL reviews are summarized below.

Orbiter. The orbiter SDR identified approximately 60 Category 1 system or component changes. Other changes were identified that will be installed on the vehicle for later flights. These changes are necessary to gain additional systems margin and to minimize risk. Figure 43 reflects several of the more important orbiter modifications.

Two of the changes for the first flight involve the main propulsion system and the reaction control system. A positive latch-open design feature for the main propulsion system disconnect valve between the orbiter and the external tank is being developed to ensure that the valve remains open during

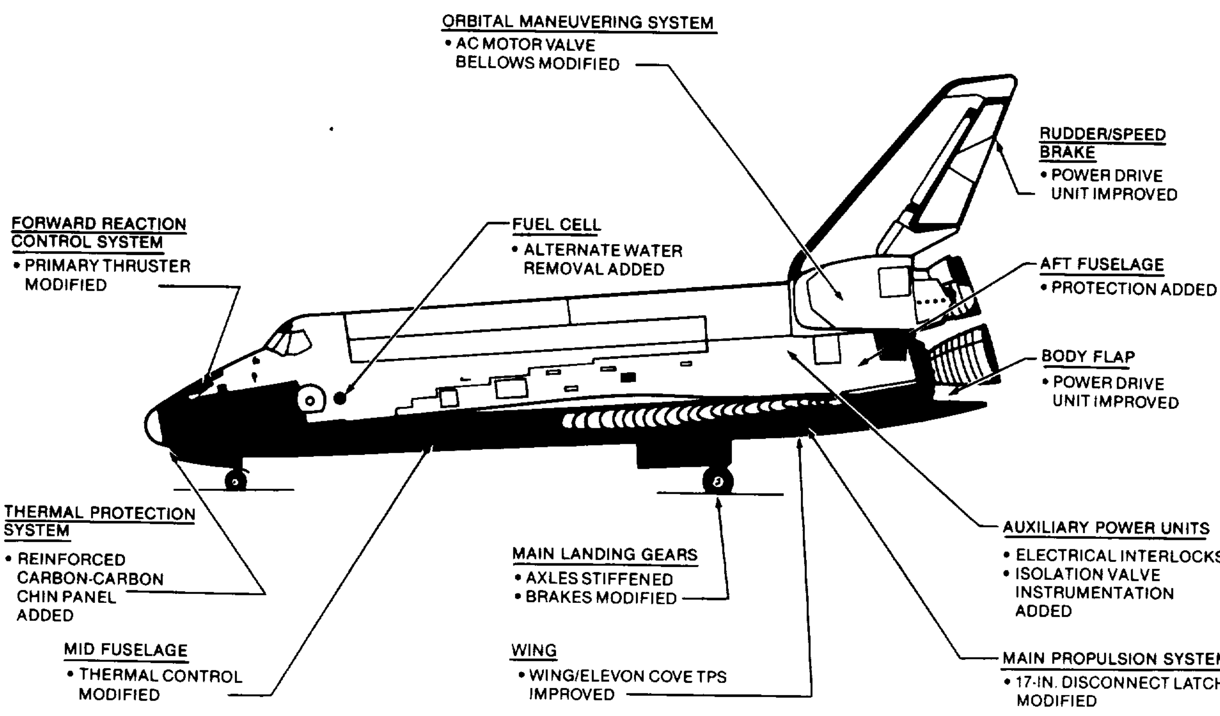

Figure 43. Major Orbiter Modifications

powered flight, even if an electrical failure occurs. The orbiter reaction control system engines, which provide on-orbit attitude control, are being modified to turn off automatically if they experience thrust instability and/or chamber wall burn-through.

Two significant design changes in the orbiter thermal protection system (TPS) have been approved. The TPS in the wing elevon cove region has been damaged on several flights, and a detailed redesign will be implemented before the next flight. A new carbon-carbon panel is being developed to replace the TPS tiles on the forward end of the orbiter between the nose cap and the nose wheel door. This panel will be phased into the flight vehicles after its verification program is completed.

Another first-flight design change in process is the addition of an electrical interlock to the auxiliary power unit tank shut-off valves to preclude electrical failures that could overheat the valves and cause decomposition of the fuel (hydrazine). Alternating-current-motor valve bellows in the orbital maneuvering system that have leaked because of improper manufacturing procedures are being replaced on a priority basis.

An improved design for the fuel cell power unit subsystem is being implemented to provide an alternate path for removing water generated by the fuel cells. This new path provides greater physical separation from the other two paths and reduces the possible loss of water-removal capability for a single freezing incident. Blockage of all these paths would result in loss of the three cells and all orbiter power within a very short time.

Space Shuttle Main Engines. Approximately 20 Category 1 changes to increase the operating life, safety, reliability, and quality of the Space Shuttle main engines (SSME's) are being implemented. The primary objective of these changes is to expand the engine operating margins in areas such as temperature, pressure, and operating time. This effort includes an enhanced engine ground test program to certify hardware improvements for nominal operation at power levels of 104 percent for the initial flights. Figure 44 shows several of the important SSME modifications.

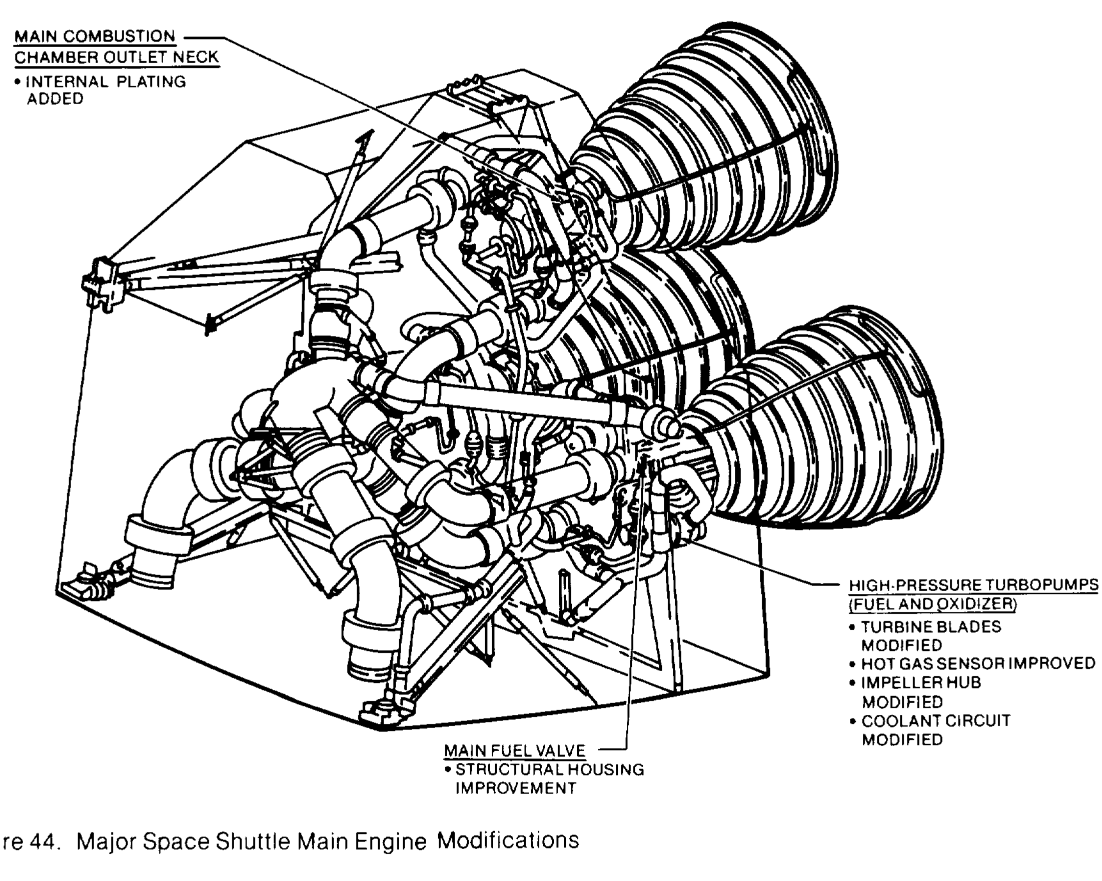

Figure 44. Major Space Shuttle Main Engine Modifications

These SSME changes include modifications to the high-pressure turbopump blades to significantly reduce the susceptibility to cracking in structurally critical areas. Improvements in structural capabilities of components such as the main fuel valve housing and the main combustion chamber outlet neck will result in significant increases (factor of 4) in useful life.

Changes to the high-pressure fuel turbopump coolant circuit will reduce the overall operating pressures and the redline (cutoff) values. The current hydraulic actuators are being replaced with actuators that have improved manufacturing cleanliness requirements and design modifications to reduce the susceptibility to electrical shorts. These changes will reduce the probability of launch pad aborts.

The engine ground test program has been emphasized and accelerated in order to demonstrate existing margins to the maximum extent possible and to certify those changes planned for incorporation prior to the return to flight. This emphasis will ensure maximum ground test exposure of the hardware, with a resultant increase in confidence prior to the resumption of flight.

External Tank. Eight changes to the external tank are required for first flight. These include strengthening the gaseous hydrogen pressurization line fairing and support structure, adding a freezer wrap to permit visual detection of a hydrogen fire, and other changes to improve the overall system safety margin.

Solid Rocket Booster. In addition to the solid rocket motor (SRM) redesign effort discussed under Recommendation I, several design changes are being implemented on the solid rocket booster (SRB) assembly in preparation for the next flight. These include changes in the ET aft attach ring structure, the SRB forward structural assembly, the aft skirt, and the ground interfaces. Figure 45 identifies the location of the major SRB modifications.

The SRB/ET aft attach ring structure is being modified from the existing structure of approximately 270-degree wraparound to a new structure with a 360-degree wraparound to increase the margin of safety. Hardware design and planning for test verification for the new attach ring are currently in progress.

Design changes, special tests, and

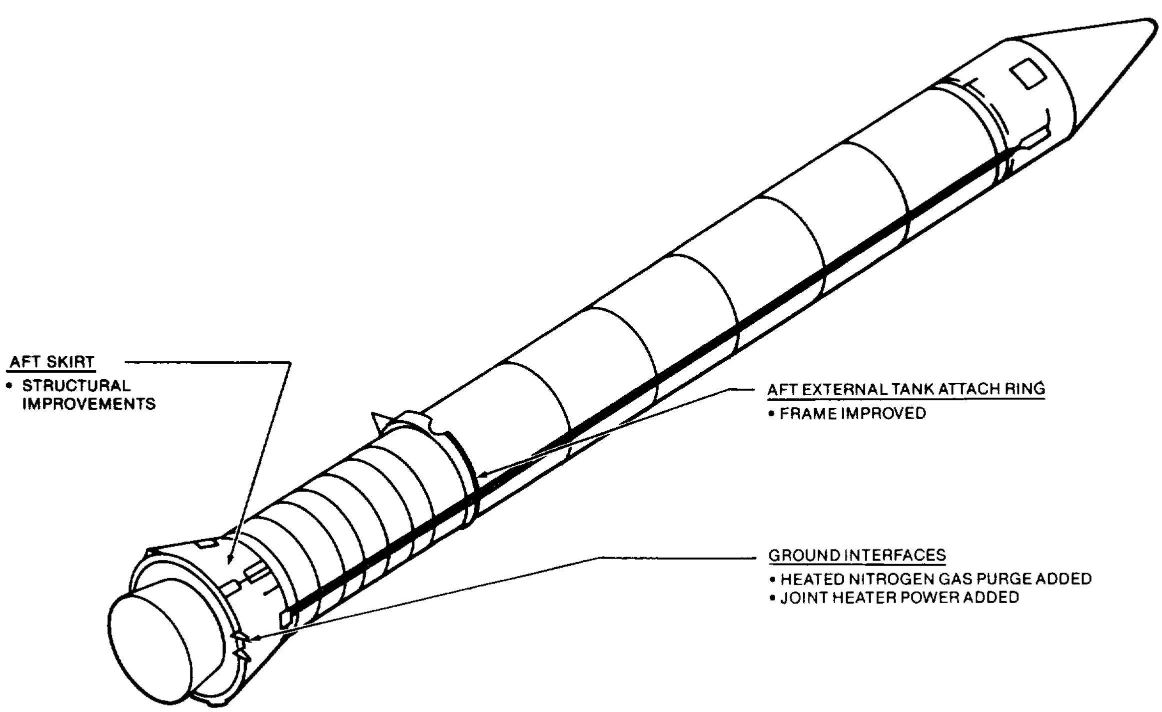

Figure 45. Major SRB Modifications

studies/assessments have been performed on the SRB forward assembly and the aft skirt structures. Improved analytical modeling techniques and better understanding of dynamic flight loads permitted identification of areas in the aft skirt structure that need to be strengthened. Structural capability is being improved by increasing the strength of selected bolts and by adding gussets and brackets.

The SRB ground interfaces are being redesigned to provide prelaunch heater power and heated nitrogen purge gas for environmental control of critical components.

Launch Processing and Ground Support Equipment. SDR activities at the Kennedy Space Center (KSC) have resulted in several facility modifications. Special debris traps have been incorporated into the ground interfaces between the orbiter and the liquid oxygen and liquid hydrogen servicing systems. These traps prevent the entry of potentially dangerous objects into the flight vehicle during propellant loading.

Wire harness and fluid line covers are being incorporated into the orbiter aft compartment area to improve protection of critical orbiter subsystem elements during ground crew servicing.

The hydrogen vent umbilical arm is being modified to increase the factor of safety, to add a more flexible vacuum-jacketed flex line, and to reduce the weight of the retractable structure. Other design improvements for the hold-down post blast shield, the orbiter emergency-egress access arm, and miscellaneous ground interface hardware are in progress.

Two new facilities, the Orbiter Maintenance and Refurbishment Building and the SRB Refurbishment Building, have recently been completed. These facilities will house activities previously conducted in the Vehicle Assembly Building, thus enhancing orbiter and SRB turnaround operations.

Design Certification Review (DCR)

A DCR will be conducted approximately 3 months prior to flight and will be similar to the initial DCR held in April 1979. The objective of the DCR is to recertify the design of all NSTS hardware and software elements. The review will be based on the updated design requirements reflected in the Space Shuttle system specification, the Shuttle ICD's, and the major element contract end item specifications. This effort will verify that the existing and new hardware and software designs are in compliance with the design requirements.

A detailed evaluation will be made of the results of the testing and analysis performed to certify that the redesigned hardware and software satisfy the program requirements for each element. The DCR will certify that the NSTS element designs meet all requirements for safe return to flight.

DOCUMENTATION IMPROVEMENTS

The program and project documentation that implements the redefined program requirements is being reviewed and updated to ensure that documents are accurate and reflect the current return-to-flight NSTS design configurations.

Master Verification Plans (MVP's)

MVP's provide the guidelines and constraints and define the rationale that is used to verify that the hardware design meets configuration, performance, inspection, and maintenance requirements. They identify the analysis and the development, acceptance, qualification, and system integrated testing that must be performed to certify the hardware for flight.

MVP's were originally prepared for each subsystem and major element before STS-1. Each element subsystem manager submitted a verification completion notice (VCN) upon successful completion of all required tests and analyses. These VCN's have been rescinded by the Director, NSTS.

Each project manager is required to reevaluate his element verification in light of the Volume X design requirement changes and any hardware design modifications made since the last subsystem certification and to submit new and/or revised VCN's as part of the DCR.

Operational Maintenance Requirements Specification Document (OMRSD)

The OMRSD defines the specific requirements for inspection, test, and checkout verification of the program hardware systems and software prior to each flight. The requirements take into consideration the fundamental checkout philosophy defined in the MVP, the CIL retention rationale for each system, and design center checkout requirements to identify those activities necessary to ensure safe operation of the vehicle during flight.

One of the specific actions under way is a complete review of the OMRSD. This review will be completed prior to the next flight and will ensure that the requirements defined in the document are complete and are consistent with the MVP and the results of the FMEA/CIL review.

Operations and Maintenance Instruction (OMI)

OMI's document the specific procedures used by KSC operational personnel to perform all activities on the flight hardware and associated ground support equipment. These instructions are being revised to include changes from the FMEA/CIL and OMRSD reviews and to improve the format.

An OMI and CIL implementation plan has been developed to ensure that test and maintenance activities involving hardware items designated Criticality 1 or 1R are prominently identified in the OMI documents.

Each operating procedure is being assessed by review teams made up of representatives from the Shuttle processing contractor, NASA (KSC and the design center), the design contractor, and SRM&QA.

OMI's are approved by the appropriate NASA design center before being released. Any deviations that affect critical items or requirements must be approved by the appropriate design center.

Launch Commit Criteria (LCC)

Launch commit criteria define the launch countdown operating limits for the ground and flight systems and provide the actions required in the event one of the limits is exceeded. LCC are used by the launch team to monitor the readiness of the vehicle in the 6-hour time period between external tank loading and lift-off.

The LCC are being modified to include the technical and operational rationale and to document the procedural workarounds, if any, that would allow the countdown to proceed in the event one of the criteria was violated. The recommended changes to the LCC are then reviewed and approved by the appropriate management levels prior to being submitted to the PRCB for final approval and publication.

NASA and its contractors began the LCC review in April 1987. The task includes assessment of results from the FMEA/CIL reviews and incorporation of all authorized hardware modifications to the vehicle. The LCC review is scheduled to be completed in November 1987.

New Documentation

The need for a set of formal element interface functional analyses to verify hardware criticality classifications and to identify failure effects across the vehicle-to-ground interfaces during turnaround operations (i.e., landing, mate/demate, element/vehicle checkout, prelaunch, and launch) was identified early in the documentation review process. These analyses have been initiated, and critical safety-related portions will be completed prior to the first flight.

A functional fault tolerance analysis of all vehicle subsystems has been initiated. This analysis will determine the synergistic and multiple failure effects between each functional subsystem and its interactive subsystems, and the resulting impacts on the total system. For a system as complex as the Shuttle, this analysis requires an extended period of time for completion. Planning to make certain that priority is given to critical systems related to overall system safety has been initiated, ensuring that analyses required for the first flight will be completed.

KSC TESTING

Because of the vehicle and launch facility modifications in progress, the long stand-down period since the last Shuttle flight, and the need for launch team training, an unmanned Shuttle vehicle wet countdown demonstration test (CDDT) and a flight readiness firing (FRF) of the Space Shuttle main engines will be conducted. These tests are required to demonstrate vehicle integrity and to ensure a safe return to flight.

Conditions to be demonstrated during these tests will be similar to the actual countdown time line and launch preparations, except for periods of the wet CDDT where special test objectives will be accomplished. Both the wet CDDT and the FRF will use modified flight and ground software, and data recorded during the CDDT will be used to confirm launch hold and abort shutdown time lines.

SSME start procedures during the FRF will be identical to those used in an actual launch, and the engines will be tested at 100-percent rated power level for approximately 20 seconds.

A detailed test readiness review will be held approximately 2 weeks prior to the CDDT and FRF to assess the test configurations and to ensure that all test preparations are in order to meet the requirements. It is planned to conduct the tests approximately 2 months prior to launch.

TRAINING

NASA has continued the training of both flight crews and flight control teams to maintain proficiency. Training, which is being conducted in all facilities, ranges from the basic level for familiarizing new personnel with NSTS systems to the intermediate level using single-system trainers and water immersion facilities to the complex level using the Shuttle mission simulator (SMS). Integrated simulations are conducted weekly using the SMS and the Mission Control Center (MCC).

Flight controller training and certification in the MCC has been strengthened and has become more rigorous. MCC personnel from each discipline are supporting the integrated simulations and are validating their respective data programs and procedures.

Flight crews are training at a reduced rate to sustain a required level of proficiency and to maintain the skills necessary to remain eligible for flight status. The crew for the next flight is very experienced and does not require a high rate of training at this time. As the launch approaches, the maximum flight crew training time in the SMS will be limited to 16 hours per week to minimize the crew work load.

Extended, integrated simulations are maintaining both flight crew and flight controllers in a state of flight readiness. Full-up vehicle systems are simulated during these simulations and require crew and MCC activities similar to those for real-time flight.

The training facilities are undergoing improvements. The SMS math models for the main propulsion system, landing and roll-out, and auxiliary power unit have been significantly upgraded, and less extensive modifications have been incorporated into other models.

Plans are being formulated to link training facilities at Johnson Space Center (JSC) and KSC to develop team coordination between flight controllers and launch controllers. Regularly scheduled training coordination meetings between JSC and Marshall Space Flight Center have facilitated mission support and training activities at each center.

LAUNCH SCHEDULE

The launch date for the first flight (STS-26) is now planned for June 1988. The exact date will depend upon completion and certification of all mandatory vehicle and engine modifications, SRB hardware delivery to KSC, orbiter processing time, and launch/flight team readiness.

STS-26 FLIGHT CREW

The five veteran astronauts (Figure 46) recently named to man the *Discovery* for the STS-26 mission are, right to left, Frederick Hauck, Richard Covey, John Lounge, David Hilmers, and George Nelson. Hauck and Nelson have flown on two previous missions, and each of the others has flown once. The crew is intimately involved in all aspects of the return-to-flight activities.

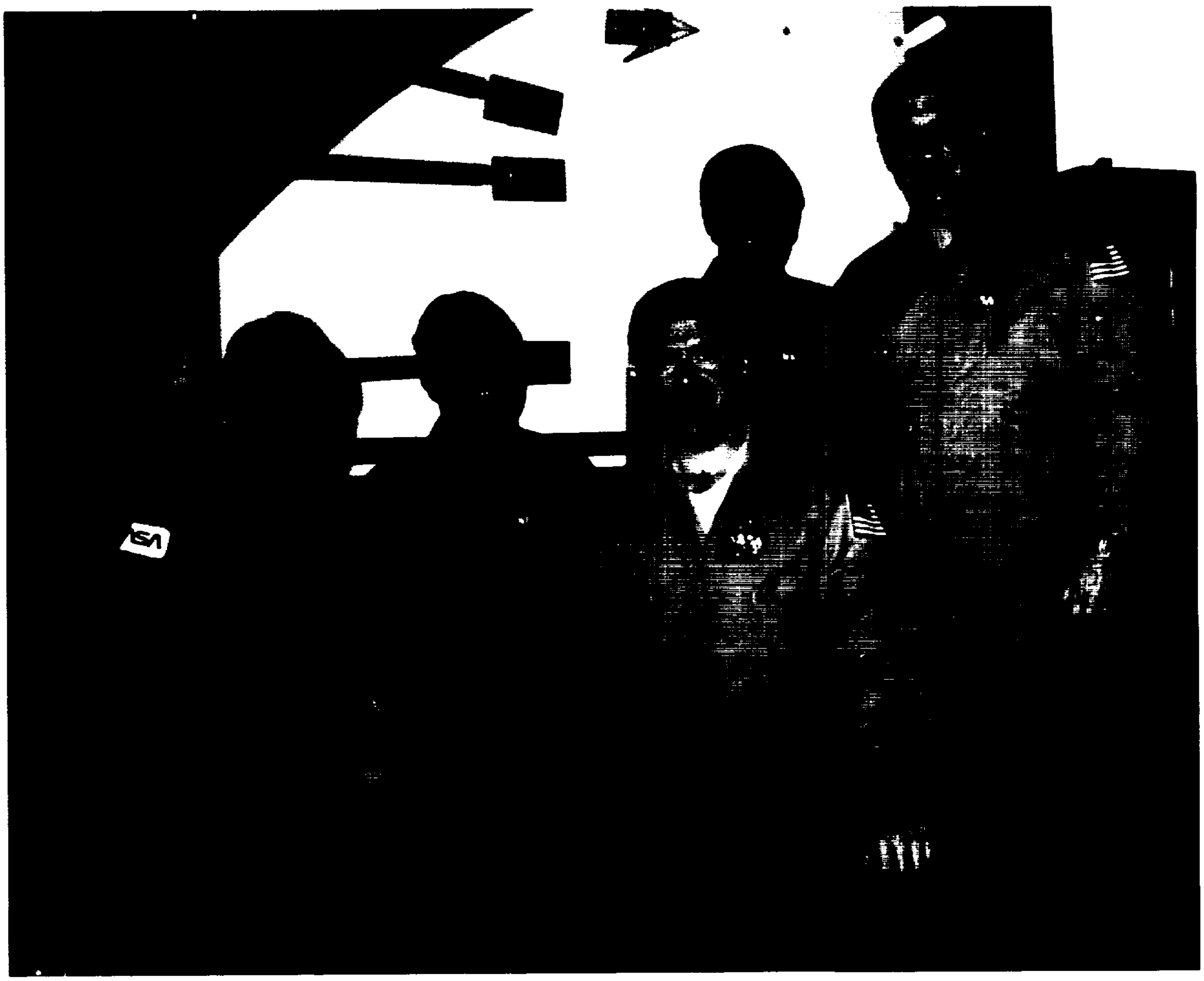

Figure 46. STS-26 Flight Crew

ORIGINAL PAGE
COLOR PHOTOGRAPH

Abbreviations and Acronyms

CDDT	countdown demonstration test
CDR	critical design review
CEES	crew egress/escape system
CIL	Critical Items List
DCR	design certification review
DM	development motor
DOD	Department of Defense
DRR	design requirements review
EAFB	Edwards Air Force Base
EIFA	element interface functional analysis
ELV	expendible launch vehicle
EOM	end of mission
ET	external tank
FAA	Federal Aviation Administration
FMEA	failure modes and effects analysis
FRF	flight readiness firing
FRR	flight readiness review
HA	hazard analysis
HDQRS	headquarters
ICD	Interface Control Document
JES	joint environment simulator
JSC	Lyndon B. Johnson Space Center
KSC	John F. Kennedy Space Center
L-1	launch minus 1 day
LCC	launch commit criteria
LRU	line replacable unit
MCC	Mission Control Center
MMT	mission management team
MSFC	George C. Marshall Space Flight Center
MVP	Master Verification Plan
NDE	nondestructive evaluation
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NSTL	National Space Technology Laboratories
NSTS	National Space Transportation System
OMI	Operations and Maintenance Instruction
OMRSD	Operational Maintenance Requirements Specification Document
OSF	Office of Space Flight
PCASS	program compliance assurance and status system
PRCB	Program Requirements Control Board
QM	qualification motor
SDR	system design review
SDV	Shuttle-derived vehicle
SIAP	System Integrity Assurance Program
SMS	Shuttle mission simulator
SRB	solid rocket booster
SRM	solid rocket motor
SR&QA	safety, reliability, and quality assurance
SRM&QA	safety, reliability, maintainability, and quality assurance
SSME	Space Shuttle main engine
STA	structural test article
STS	Space Transportation System
TPS	thermal protection system
USAF	United States Air Force
VCN	verification completion notice

Appendix A.

National Research Council Members and Summary of Responsibilities for the Solid Rocket Motor Redesign Committee

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NATIONAL RESEARCH COUNCIL

Panel on Redesign of the Space Shuttle Solid Rocket Motor

In response to the first recommendation of the Presidential Commission on the Space Shuttle *Challenger* Accident, the NASA Administrator requested that the National Research Council form an independent committee of recognized experts to provide an overview of the activities of the solid rocket motor redesign effort.

The overview committee was specifically requested to review and evaluate the certification requirements and to provide technical oversight over the design, test procedures, and manufacture and assembly of test motors. The committee was also asked to review and evaluate the test and certification program, and to make recommendations to the NASA Administrator as to the adequacy of the design in meeting all requirements.

NATIONAL RESEARCH COUNCIL

Panel on Redesign of the Space Shuttle Solid Rocket Motor

H. Guyford Stever, Chairman
Foreign Secretary
National Academy of Engineering

Laurence J. Adams
Former President
Martin Marietta Corporation

David Altman
Former Senior Vice President
Chemical Systems Division, UTC

Robert C. Anderson
Former Vice President
TRW Energy Development Group
Electronics & Defense Sector

Jack L. Blumenthal
Chief Engineer
TRW
Materials and Chemistry Applications

Robert C. Forney
Executive Vice President
E.I. DuPont de Nemours & Co., Inc.
Administration Department

Alan N. Gent
Professor of Polymer Physics
The Institute of Polymer Science
University of Akron

Dean K. Hanink
Former Manager of Engineering
Operations, Detroit Diesel

James W. Mar, Vice Chairman
Jerome C. Hunsaker Professor of
Aerospace Education
Dept. of Aeronautics & Astronautics
Massachusetts Institute of Technology

Edward W. Price
Regents' Professor
School of Aerospace Engineering
Georgia Institute of Technology

Robert D. Watt
Former Group Leader
Stanford Linear Accelerator Center

National Research Council Staff

Myron F. Uman
Project Director

Robert H. Korkegi
Director
Committee on NASA Scientific and
Technological Program Reviews

Panel Meeting Participants

Melvin Stone
Former Director of Structures
McDonnell Douglas
(Observer from NASA's Aerospace
Safety Advisory Panel)

Edward J. Barlow
Former Vice President
Varian Associates
(Observer from NRC's Reports
Review Committee)

Russell Bardos
Shuttle Propulsion Office
(NASA Headquarters Liaison)

Appendix B.

Solid Rocket Motor NASA/Industry Overview Committee Members and Summary of Responsibilities

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NASA/INDUSTRY

Solid Rocket Motor Team Overview Committee

In support of the solid rocket motor redesign, the MSFC center director named an overview committee of NASA and industry executives to independently review the design activities. Dr. Allan Norton, Vice President of Martin Marietta/Orlando Aerospace, was asked to serve as chairman of the committee, and John Young was appointed as the representative from the Astronaut Office.

This overview committee has actively participated in the redesign effort and has made specific recommendations concerning redesign approaches; development, qualification, and certification test requirements; and control of the production process to ensure the availability of a reliable and safe design.

The committee has recommended programmatic approaches that should be considered in accomplishing the redesign and associated tasks in a responsible and timely manner.

NASA/INDUSTRY

Solid Rocket Motor Team Overview Committee

Allan Norton, Chairman
Vice President, Electronic Systems
Martin Marietta/Orlando Aerospace

Michael Card
Chief, Structures and Dynamics Division
NASA Langley Research Center

Henry Pohl
Director, Engineering
NASA Johnson Space Center

Maxine Faget
President and Chief Executive
Space Industries, Incorporated

Charles Feltz
Former President
STS Development and Production Division
Rockwell International

Leonard Harris
Chief of Engineering for Office of
Aeronautics and Space Technology
NASA Headquarters

Horace Lamberth
Director and Vice President
Shuttle and Ground Support Engineering
Lockheed Space Operations Corporation

Adrian O'Neal
Vice President and General Manager
McDonnell Douglas Corp., Huntsville

Dominic Sanchini
President, Rocky Flats Plant
Rockwell International

Samuel Tennant
Vice President, Programs Group
Aerospace Corporation

David L. Winterhalter
Director, Systems Engineering and
Analysis Directorate
NASA Headquarters

John Young
Special Assistant for Engineering,
Operations, and Safety
NASA Johnson Space Center

Appendix C.

Strategy for Safely Returning the Space Shuttle to Flight Status

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

MAR 24 1986

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Strategy for Safely Returning the Space Shuttle to Flight Status

This memorandum defines the comprehensive strategy and major actions that, when completed, will allow resumption of the NSTS flight schedule. NASA Headquarters (particularly the Office of Space Flight), the OSF centers, the National Space Transportation System (NSTS) program organization and its various contractors will use this guidance to proceed with the realistic, practical actions necessary to return to the NSTS flight schedule with emphasis on flight safety. This guidance is intended to direct planning for the first year of flight while putting into motion those activities required to establish a realistic and an achievable launch rate that will be safely sustainable. We intend to move as quickly as practicable to complete these actions and return to safe and effective operation of the National Space Transportation System.

Guidance for the following subjects is included:

- ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT
- FIRST FLIGHT/FIRST YEAR OPERATIONS
- DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT:

Reassess Entire Program Management Structure and Operation

The NSTS program management philosophy, structure, reporting channels and decision-making process will be thoroughly reviewed and those changes implemented which are required to assure confidence and safety in the overall program, including the commit to launch process. Additionally, the Level I/II/III budget and management relationships will be reviewed to insure that they do not adversely affect the NSTS decision process.

25th Anniversary

Solid Rocket Motor (SRM) Joint Redesign

A dedicated SRM joint design group will be established at MSFC, with selective participation from other NASA centers and external organizations, to recommend a program plan to quantify the SRM joints problem and to accomplish the SRM joints redesign. The design must be reviewed in detail by the program to include PDR, CDR, DCR, independent analysis, DM-QM testing, and any other factors necessary to assure that the overall SRM is safe to commit to launch. The type and content of post-flight inspections for the redesigned joints and other flight components will be developed in detail, with criteria developed for commitment to the next launch as well as reusability of the specific flight hardware components.

Design Requirements Reverification

A review of the NSTS Design Requirements (Vol. 07700) will be conducted to insure that all systems design requirements are properly defined. This review will be followed by a delta DCR for all program elements to assure the individual projects are in compliance with the requirements.

Complete CIL/OMI Review

All Category 1 and 1R critical items will be subjected to a total review with a complete reapproval process implemented. Those items which are not revalidated by this review must be redesigned, certified, and qualified for flight. The review process will include a review of the OMI's, OMRSD's, and other supporting documentation which is pertinent to the test, checkout, or assembly process of the Category 1 and 1R flight hardware. KSC will continue to be responsible for all OMI's with design center concurrence required for those which affect Category 1 and 1R items. Category 2 and 3 CIL's will be reviewed for reacceptance and to verify their proper categorization.

Complete OMRSD Review

The OMRSD will be reviewed to insure that the requirements defined in it are complete and that the required testing is consistent with the results of the CIL review. Inspection/retest requirements will be modified as necessary to assure flight safety.

Launch/Abort Reassessment

The launch and launch abort rules and philosophy will be assessed to assure that the launch and flight rules, range safety systems/ operational procedures, landing aids, runway configuration and length, performance vs. TAL exposure, abort weights, runway surface, and other landing related capabilities provide an acceptable margin of safety to the vehicle and crew. Additionally, the weather forecasting capability will be reviewed and improved where possible to allow for the most accurate reporting.

FIRST FLIGHT/FIRST YEAR OPERATIONS

First Flight

The subject of first flight mission design will require extensive review to assure that we are proceeding in an orderly, conservative, safe manner. To permit the process to begin, the following specific planning guidance applies to the first planned mission:

- daylight KSC launch
- conservative flight design to minimize TAL exposure
- repeat payload (not a new payload class)
- no waiver on landing weight
- conservative launch/launch abort/landing weather
- NASA-only flight crew
- engine thrust within the experience base
- no active ascent/entry DTO's
- conservative mission rules
- early, stable flight plan with supporting flight software and training load
- daylight EDW landing (lakebed or runway 22)

First Year

The planning for the flight schedule for the first year of operation will reflect a launch rate consistent with this conservative approach. The specific number of flights to be planned for the first year will be developed as soon as possible and will consider KSC and VAFB work flow, software development, controller/crew training, etc. Changes to flight plans, ascent trajectories, manifest, etc., will be minimized in the interest of program stability. Decisions on each launch will be made after thorough review of the previous mission's SRM joint performance, all other specified critical systems performance and resolution of anomalies.

In general, the first year of operation will be maintained within the current flight experience base, and any expansion of the base, including new classes of payloads, will be approved only after very thorough safety review. Specifically, 109 percent thrust levels will not be flown until satisfactory completion of the MPT testing currently being planned, and the first use of the Filament Wound Case will not occur with the first use of 109 percent SSME thrust level. Every effort will be made to conduct the first VAFB flight on an expeditious and safe schedule which supports national security requirements.

DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

The ultimate safe, sustainable flight rate, and the buildup to that rate, will be developed utilizing a "bottoms-up" approach in which all required work for the standard flow as defined in the OMRSD is identified and that work is optimized in relation to the available work force. Factors such as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, work balancing across shifts, etc., will be considered, as well as timely mission planning, flight product development and achievable software delivery capability to support flight controllers and crew training. This development will consider the availability of the third orbiter facility, the availability of spares, as well as the effects of supporting VAFB launch site operations.

THE BOTTOM LINE

The Associate Adminstrator for Space Flight will take the action for reassessment of the NSTS program management structure. The NSTS Program Manager at Johnson Space Center is directed to initiate and coordinate all other actions required to implement this strategy for return to safe Shuttle flight.

I know that the business of space flight can never be made to be totally risk-free, but this conservative return to operations will continue our strong NASA/Industry team effort to recover from the Challenger accident. Many of these items have already been initiated at some level in our organizations, and I am fully aware of the tremendous amount of dedicated work which must be accomplished. I do know that our nation's future in space is dependent on the individuals who must carry this strategy out safely and successfully. Please give this the widest possible distribution to your people. It is they who must understand it, and they who must do it.

Richard H. Truly

Distribution:
AD/A/Dr. Graham
A/Dr. Williams
ADB/Ms. Bradley
AS/Mr. Culbertson
B/Mr. Newman
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T/Mr. Aller
U/Dr. Jenkins
W/Mr. Colvin
ARC/D/Dr. Ballhaus, Jr.
GSFC/100/Dr. Hinners
JPL/180-904/Dr. Allen
JSC/AA/Mr. Moore
KSC/CD/Mr. Smith
LaRC/0100/Mr. Petersen
LeRC/0100/Mr. Stofan
MSFC/DA01/Dr. Lucas
NSTL/AA00/Mr. Hlass
JSC/AE/Mr. Cohen
JSC/AM/Mr. Charlesworth
JSC/CA/Mr. Abbey
JSC/CB/Mr. Young
JSC/DA/Mr. Kranz
JSC/GA/Mr. Aldrich
JSC/TA/Mr. Nicholson
JSC/VA/Mr. Colonna
KSC/CM/Mr. Conway
KSC/SE/Mr. Lamberth
KSC/SM/Mr. Sieck
LeRC/6000/Mr. Ross
LeRC/6300/Mr. Szabo
MSFC/EA01/Mr. Kingsbury
MSFC/FA01/Mr. Reinartz
MSFC/SA31/Mr. Bridwell
MSFC/SA41/Mr. Mulloy
MSFC/SA51/Mr. Taylor
ASAP/Mr. Roth
USAF/Mr. Aldridge
AFSC/Gen. McCartney

Appendix D.

Organization and Operation of the NSTS Program

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Organization and Operation of the National Space Transportation System (NSTS) Program

This memorandum defines direction for the organization and operation of the NSTS program. This direction has been reviewed by the NASA Management Study Group led by General Phillips and has the approval of the Administrator. This implements the NASA response to Recommendation II (Shuttle Management Structure) and Recommendation V (Communications) of the Presidential Commission on the Space Shuttle Challenger Accident.

A crucial part of our strategy to safely return the Space Shuttle to flight status, as outlined in my memorandum of March 24, 1986 (and later reinforced by the Presidential Commission), has been a reassessment of the NSTS program management structure and operation. On June 25, 1986, in order to form the basis for a careful assessment of the management of the NSTS and required adjustments, if any, I directed Robert L. Crippen to lead a study of NSTS program operation and organization. This study has been presented to me and, subsequently, reviewed with all incumbent managers of the NSTS program through the project level; all involved field Center Directors (Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), Johnson Space Center (JSC), and National Space Technology Laboratories (NSTL)); and staff members of the Headquarters Office of Space Flight.

Decisions relating to the following program areas have resulted from this deliberation:

- NSTS MANAGEMENT STRUCTURE
- NSTS PROGRAM EXECUTION
- IMPLEMENTATION
- RELATIONSHIP OF THE CENTER DIRECTORS TO THE NSTS PROGRAM

A detailed discussion of each of these subjects follows in this memorandum.

NSTS PROGRAM EXECUTION

Flow of NSTS Program Direction and Response

NSTS program direction and response will flow from the Director, NSTS, through the Deputy Director, NSTS Program, to the various Project Managers and vice versa.

In this programmatic chain, the managers of the project elements located at the various field Centers will report to the Deputy Director, NSTS Program. Depending upon individual Center organization, this chain is either direct (such as the Orbiter Project Office at JSC) or via an intermediate office (such as the Shuttle Projects Office at MSFC). The MSFC Shuttle Projects Office is a management integration function and does not preclude direct interaction between the MSFC Project Managers and the Deputy Director, NSTS Program. The Manager, Shuttle Projects Office, located at MSFC, will be a Headquarters employee reporting directly to the Deputy Director, NSTS Program. The MSFC Center Director will fully support the personnel and facility requirements of the Manager, Shuttle Projects Office.

Budget Procedures and Control within the NSTS Program

The NSTS program budget will continue to be submitted through the Center Directors to the Director, NSTS, who will have total funding authority for the program. The Deputy Directors, NSTS Program and NSTS Operations, will each provide an assessment of the budget submittal to the Director, NSTS, as an integral part of the decision process, and their recommendations will be key to the final budget decisions. Following the final budget mark by the Associate Administrator for Space Flight, the Centers will submit a mark implementation plan, reconciling budget and program content, which will also be reviewed and concurred in by the Deputy Directors, NSTS Program and NSTS Operations, then approved by the Director, NSTS.

The Deputy Directors', NSTS Program and NSTS Operations, budgets will be established and managed directly as part of the NSTS budget. Their budgets, although not submitted as part of the Center budgets, will continue to be supported by the Center procurement and financial management organizations.

IMPLEMENTATION

The Director, NSTS, is charged with implementing this direction for the organization and operation of the NSTS program by revising appropriate NASA Management Instructions and program documentation. In addition, the Program Director shall act on the detailed recommendations of the Crippen study, exclusive of the recommendation on Astronauts in Management, which will be acted on by the Associate Administrator for Space Flight.

NSTS MANAGEMENT STRUCTURE

Director, NSTS

The position of Director, NSTS, is established. In addition, the Director, NSTS, shall have two Deputies--Deputy Director, NSTS Program, and Deputy Director, NSTS Operations. This triad shall act as a single entity to manage the NSTS program. The Director, NSTS, is at the level of Deputy Associate Administrator and reports directly to me. He will have full responsibility and authority for the operation and conduct of the NSTS program. This will include total program control with full responsibility for budget, schedule, and balancing program content. The Director, NSTS, is responsible for overall program requirements and performance. He shall have sufficient staff/systems engineering support at Headquarters to accomplish this activity. The Director, NSTS, is the approval authority for top level program requirements, critical hardware waivers, and for budget authorization adjustments that exceed a predetermined level.

Deputy Director, NSTS Program

The Deputy Director, NSTS Program, who reports directly to the Director, NSTS, and his senior managers will be Headquarters employees. They are responsible for the day-to-day management and execution of the NSTS program. This includes detailed program planning, direction, and scheduling and STS system configuration management. Other responsibilities include system engineering and integration for the STS vehicle, ground facilities, and cargos. The NSTS Engineering Integration Office, reporting to the Deputy Director, NSTS Program, is established and directly participates with each NSTS project element (Space Shuttle Main Engine, Solid Rocket Booster, External Tank, Orbiter, and Launch and Landing System). The Deputy Director, NSTS Program, will be located at the Johnson Space Center. The JSC Center Director will fully support the personnel and facility requirements of the Deputy Director, NSTS Program.

Deputy Director, NSTS Operations

The Deputy Director, NSTS Operations, a Headquarters employee reporting directly to the Director, NSTS, is responsible for all operational aspects of the missions. This includes final vehicle preparation, mission execution, and return of the vehicle for processing for its next flight. The Deputy Director, NSTS Operations, will present the Flight Readiness Review (FRR) which will be chaired by the Associate Administrator for Space Flight, manage the final launch decision process, and chair the Mission Management Team (MMT). He will be supported by a small staff located at KSC, MSFC, JSC, and Headquarters. These personnel shall remain employees of their respective Centers but report directly to the Deputy Director, NSTS Operations. The KSC, MSFC, and JSC Center Directors will fully support the facility and personnel requirements of the Deputy Director, NSTS Operations.

RELATIONSHIP OF THE CENTER DIRECTORS TO THE NSTS PROGRAM

Responsibilities of the Center Directors to the NSTS Program

As with other programs and projects located at their Centers, the Center Directors are responsible and accountable for the technical excellence and performance of each of the NSTS project elements at their respective Center. Further, the Center Directors will ensure that their institution provides the required support to the NSTS program.

Revitalization of the OSF Management Council

A key element of the ultimate success of the Office of Space Flight is a revitalization of the OSF Management Council. The OSF Management Council will consist of:

Associate Administrator, Office of Space Flight
Director, Marshall Space Flight Center
Director, Kennedy Space Center
Director, Johnson Space Center
Director, National Space Technology Laboratories

The Council will meet on a regular basis, with agendas published in advance, and will oversee all OSF responsibilities, including the NSTS.

Richard H. Truly

Distribution:
A/Dr. Fletcher
AD/Mr. Myers
AE/Dr. Williams
ADB/Ms. Bradley
AS/Mr. Culbertson
B/Mr. Newman
C/Mr. Murphy
E/Dr. Edelson
F/Mr. Terrell
G/Mr. O'Brien
H/Adm. Evans
I/Mr. Gillam
K/Mr. Rosen
L/Capt. Hauck
M/Senior Staff
N/Mr. Nysmith
P/Dr. McDonald
Q/Mr. Rodney
R/Dr. Colladay
S/Mr. Stofan
T/Mr. Aller
U/Dr. Jenkins
W/Mr. Colvin
ARC/D/Dr. Ballhaus
GSFC/100/Dr. Hinners
JPL/100/Dr. Allen
JSC/AA/Dr. Cohen
KSC/CD/Gen. McCartney
LaRC/0100/Mr. Petersen
LeRC/0100/Dr. Klineberg
MSFC/DA01/Mr. Thompson
NSTL/AA00/Mr. Hlass
JSC/CA/Mr. Abbey
JSC/CB/Mr. Young
JSC/DA/Mr. Kranz
JSC/GA/Mr. Aldrich
JSC/TA/Mr. Nicholson
JSC/VA/Mr. Colonna
KSC/CM/Mr. Conway
KSC/SE/Mr. Lamberth
KSC/SM/Mr. Sieck
LeRC/6000/Mr. Ross
LeRC/6300/Mr. Szabo
MSFC/EA01/Mr. Odom
MSFC/SA01/Mr. Marshall
MSFC/SA11/Mr. Lombardo
MSFC/SA31/Mr. Bridwell
MSFC/SA41/Mr. Smith
MSFC/SA51/Mr. Taylor
ASAP/Mr. Sutter
USAF/Mr. Aldridge
USAF/Gen. Randolph
AFSC/Gen. Casey

Appendix E.

NASA Management Instruction on Space Flight Safety Panel

NASA Management Instruction

NMI 1152.66
Effective Date January 9, 1987
Expiration Date January 9, 1990

Responsible Office: M/Office of Space Flight

Subject: NASA Space Flight Safety Panel

1. PURPOSE

This instruction establishes the NASA Space Flight Safety Panel and sets forth its functions, responsibilities, and membership.

2. APPLICABILITY

This instruction is applicable to all NASA installations and activities, particularly NASA space flight programs involving flight crews.

3. ESTABLISHMENT

The NASA Space Flight Safety Panel (hereafter referred to as the "Panel") is hereby established for promoting flight safety for all NASA employees associated with NASA space flight programs involving flight crews. The Panel reports to the Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance.

4. FUNCTIONS

The functions for the NASA Space Flight Safety Panel are to:

a. Promote a NASA Space Flight Safety Program for those space programs involving flight crews, and to advise and assist the appropriate Associate Administrators in the administration and monitoring of this program. The program's purpose is to preserve human and material resources in order to enhance efficient space flight operations. The scope of the Panel's purview will encompass all aspects of the manned space program which affect flying safety.

b. Provide an independent communication link to the Associate Administrator for Space Flight, Associate Administrator for Space Station, Associate Administrator for Space Science and Applications, and the Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance, in matters pertaining to space flying safety. In this regard, the Panel will publicize its functions and actively encourage all levels of personnel, government and contractor, to detect and eliminate hazards which could adversely affect the accomplishment of the manned space flight objectives.

5. RESPONSIBILITIES

a. The Chairperson is responsible for:

(1) Reporting to the Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance.

(2) Actively participating in the development of the NASA Space Flight Safety Program and provide an independent assessment of its scope, implementation and effectivity.

(3) Supporting the Associate Administrator for Space Station, Associate Administrator for Space Science and Applications, and the Associate Administrator for Space Flight in all matters pertaining to space flight safety.

(4) Calling meetings of the Panel at least every 2 months and approving the agenda for the meetings.

(5) Attending all Level I Flight Readiness Reviews.

b. Members of the Panel are responsible for:

(1) Working with the Chairperson to ensure that a viable pervasive NASA Space Flight Safety Program is established and maintained.

(2) Promoting the NASA Space Flight Safety Program.

(3) Ensuring that the Panel properly reviews and comments on all launch commit criteria and mission rules.

(4) Soliciting and responding to space flight safety concerns.

6. MEMBERSHIP

a. The Chairperson and Panel members will be appointed by the Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance and will include as a minimum:

(1) An astronaut who has flown on a NASA mission.

(2) A Johnson Space Center Flight Director.

(3) A Marshall Space Flight Center Mission Manager.

(4) A Kennedy Space Center Launch Director or NASA Test Director.

b. Membership, including the Chairperson, will be for a period of 2 years. Initial rotation shall be staggered by at least 4 months for each individual, commencing 1 year after formation of the Panel.

7. MEETINGS

The Panel will meet at least every 2 months at the request of the Chairperson or as requested by the Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance.

James C. Fletcher
Administrator

DISTRIBUTION:
SDL 1

Appendix F.

National Research Council Members and Summary of Responsibilities for the Criticality Review and Hazard Analysis Audit Committee

NATIONAL RESEARCH COUNCIL

Shuttle Criticality Review and Hazard Analysis Audit Committee

In response to the third recommendation of the Presidential Commission on the Space Shuttle *Challenger* Accident, the NASA Administrator requested that the National Research Council form an audit panel to review the NSTS Program's criticality item and hazard analysis reassessment effort.

The audit committee was specifically requested to audit the approach taken for the program review activity and to verify the adequacy of the overall reassessment, and report their conclusions and recommendations to the NASA Administrator.

NATIONAL RESEARCH COUNCIL

Shuttle Criticality Review and Hazard Analysis Audit Committee

General (USAF ret.) Alton D. Slay, Chairman
Slay Enterprises
(Former Commander, USAF
Systems Command)

Gerald W. Elverum, Jr.*
Vice President and General Manager
TRW
Applied Technology Division

Dr. Grant . Hansen*
Consultant
(Former Vice President
Systems Development Corporation)

Willis M. Hawkins*
Senior Advisor
Lockheed Corporation
(Former Senior Vice President)

Ira G. Hedrick*
Senior Management Consultant
Grumman Corporation
(Former Senior Vice President)

Dr. A. Bruce Hoadley
Division Manager, Analytical Methods
and Software Systems
Bellcom

Dr. William B. Lenior
Space Systems Development &
Commercialization of Space
Booz-Allen & Hamilton
(Former Astronaut)

Dr. Artur Mager*
Consultant
(Former Group Vice President
The Aerospace Corporation)

Dr. Norman R. Parmet
Consultant
(Former Vice President—Engineering
& Quality Assurance, TWA)

Dr. Robert E. Uhrig
Distinguished Professor of
Engineering
Dept. of Nuclear Engineering
University of Tennessee

Dr. James J. Kramer
(Ex Officio Chairman,
Aeronautics & Space Energy Board)
Manager, Advanced Technical Programs
General Electric Company

*Member, National Academy of Engineering

Appendix G.

NASA Management Instruction on Roles and Responsibilities of the Office of Associate Administrator for Safety, Reliability, Maintainability, and Quality Assurance

NASA

Management Instruction

NMI 1103.39A
Effective Date December 15, 1986
Expiration Date December 15, 1989

Responsible Office: Q/Office of SRM&QA

Subject: ROLE AND RESPONSIBILITIES - ASSOCIATE ADMINISTRATOR FOR SAFETY, RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE (SRM&QA)

1. OBJECTIVES OF POSITION

   a. Provide for the planning, direction, implementation, and evaluation of that part of the overall NASA program concerned with systems assurance including safety, reliability, maintainability, and quality assurance (SRM&QA).

   b. Assure that the Administrator and other principal officials are aware of matters pertaining to the technical execution and physical readiness of NASA programs/projects.

   c. Provide for overall technical review of NASA programs/projects to ensure development efforts and mission operations are being conducted on a sound engineering basis with proper controls and attention to development risk.

   d. Provide NASA competition advocacy guidance and oversight in accordance with the provisions of NMI 1210.2.

2. ORGANIZATIONAL SETTING

   a. Reports to the Administrator.

   b. The basic organization chart for the Office of SRM&QA is shown in Attachment A.

3. RESPONSIBILITIES

   The Associate Administrator for SRM&QA has the following responsibilities and is delegated the authority to carry out these responsibilities:

   a. Responsible for a systems assurance program that provides focus to those activities that will enhance operational success of NASA programs/projects. Administratively responsible for SRM&QA functions related to NASA programs/projects, and assurance that SRM&QA and technical issues and lessons learned are fully considered during Design Reviews, Flight Readiness Reviews, Test Readiness Reviews, Operational Readiness Reviews, or equivalent formal reviews that are conducted prior to start-up of operations for ground facilities, manned and unmanned launch operations, aircraft flight programs, and acceptance testing of experimental facilities and hardware having significant risk to persons or property. The systems assurance program will monitor the status of equipment, software, validation of design, problem analysis, and system acceptability.

b. Direction of reporting and documentation of problem identification, problem resolution, and trends. Ensure that a fully documented trend analysis program is conducted that includes accurate reporting of anomalies, thorough analysis and testing of problems, and implementation of corrective measures.

c. Ensure that SRM&QA policies, plans, procedures, and standards are established, documented, maintained, communicated, and implemented. Perform SRM&QA surveys of field installations to assess the implementation of Headquarters policy and guidance. Provide policy interpretation to field installations and assist in their implementation as required (reference dotted line reporting of Center Safety, Reliability, and Quality Assurance Directors on attached organization chart). Participate with field installations in SRM&QA surveys of prime and subcontractors or wherever problems dictate need for such surveys.

d. Ensure that field installation SRM&QA organizations are staffed with sufficient, qualified personnel to allow accomplishment of assigned tasks.

e. Review safety practices and standards and their application to specific programs/projects. Conduct an organized, systematic approach to identify and control hazards, ensuring that safety factors are fully considered from conception to completion of all NASA activities. Analyze and categorize the potential of the hazards or failures, and ensure that detailed operating and emergency procedures or administrative controls are developed to overcome or reduce the hazards or the effects of the failures if they cannot be eliminated or reduced to acceptable levels by design or engineering changes.

f. Provide policy and requirements for establishing a maintainability assurance program, where applicable. Provide design inputs to promote maintainability by considering areas such as accessibility, testability, handling provisions, ease of installation, and work constraints. Develop spares provisioning requirements and supporting operational data.

g. Direct the thorough, prompt, and accurate investigation, reporting, and analysis of all NASA mishaps, incidents, and accidents. Ensure resolution of all investigation-related recommendations. Serve as chair or ex-officio member of all mission failure review boards established by the Administrator, and participate as appropriate in the proceedings of all such boards established by other NASA officials.

h. Conduct independent reviews of programs and programmatic controls within NASA and within the contractor structure. Perform special reviews at the request of the Administrator and support Program Offices in special review activities.

i. On a selective basis, review the technical management and engineering aspects of those requests for proposals which are designated in the Master Buy Plan for Headquarters review and approval. On the same basis, as appropriate, review requests for proposals for Center-controlled programs. Participate in, or be represented at, Source Evaluation Board presentations which involve procurements with technical dimensions.

j. Provide an oversight function to ensure NASA's advanced programs and long range plans recognize SRM&QA requirements, practices, and lessons learned.

k. Provide an integrated focus for engineering standards and policies. Direct a program to review existing standards for application to specific programs/projects, and to develop new standards or policies, where appropriate.

l. Provide NASA competition advocacy and oversight. As the NASA Competition Advocate, responsible for NASA-wide efforts to enhance competition, and for challenging barriers to, and promoting, full and open competition in the procurement of property and services.

4. <u>RELATIONSHIP TO OFFICE OF INSPECTOR GENERAL</u>

Nothing in this Instruction shall be interpreted to diminish, denigrate, or limit the independent authorities and functions of the Office of Inspector General.

5. <u>LINE OF SUCCESSION</u>

Officials authorized to act for the Associate Administrator for SRM&QA are listed in Attachment B.

6. <u>CANCELLATION</u>

NMI 1103.1D dated August 6, 1982, and NMI 1103.39 dated July 3, 1986.

James C. Fletcher
James C. Fletcher
Administrator

<u>ATTACHMENT:</u>
A. Organization Chart for the Office of SRM&QA.
B. Authority to Act for the AA for SRM&QA.

SUBJECT: AUTHORITY TO ACT FOR THE ASSOCIATE ADMINISTRATOR FOR SRM&QA DURING NORMAL CONDITIONS OR IN THE EVENT OF AN ATTACK ON THE UNITED STATES

1. DELEGATION

   a. Scope of Authority. Whenever the Associate Administrator for SRM&QA is unable for any reason to perform assigned duties during normal conditions or in the event of an attack on the United States, the permanently assigned incumbents of the positions listed in subparagraph b. are authorized to serve in the order listed as Acting AA for SRM&QA and to carry out all functions, powers, and duties of such position pursuant to law, except the duty of the AA for SRM&QA to succeed to any other NASA position.

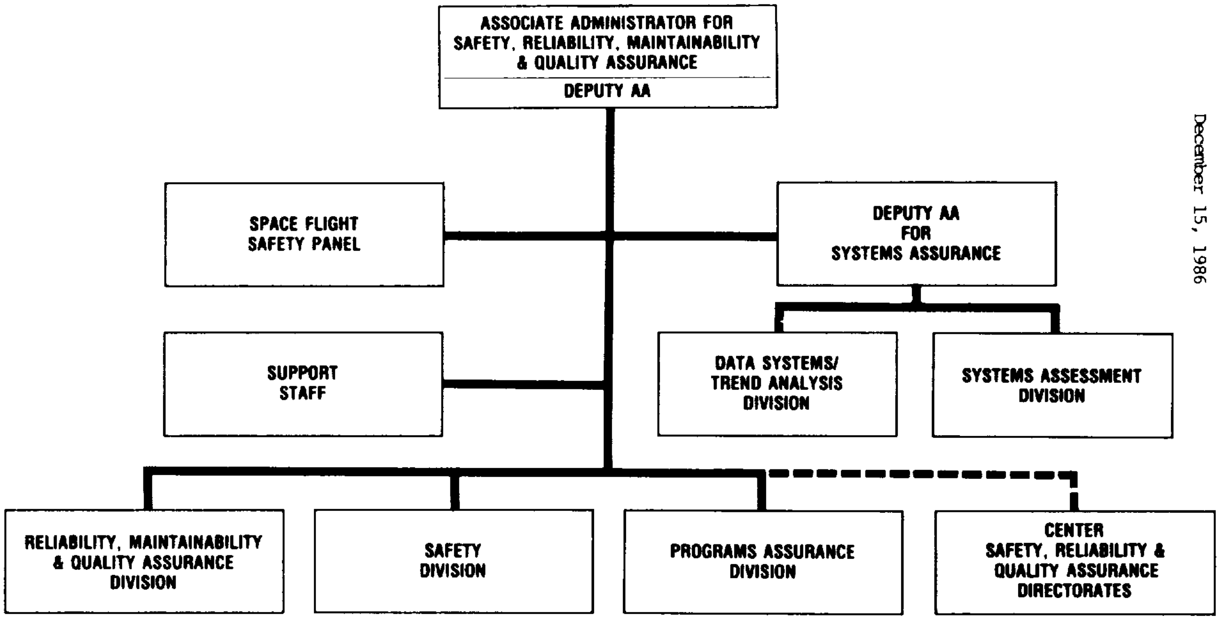
   b. Officials Designated.

      (1) Deputy AA for SRM&QA
      (2) Deputy AA for Systems Assurance
      (3) Director, Safety Division

2. REDELEGATION

   None authorized.

December 15, 1986



APPROVED: James Fletcher

DATE: Dec. 19, 1986

ATTACHMENT A
NMI 1103.39A

Attachment A
NMI 1103.39A

FILE NAME: Q/SRM&QAOrg

NASA HQ Q 9-16-86

Appendix H.

Actions to Implement the Recommendations of the Presidential Commission on the Space Shuttle *Challenger* Accident

National Aeronautics and Space Administration

Report to the President

Actions to Implement the Recommendations

of The Presidential Commission on the Space Shuttle Challenger Accident

July 14, 1986
Washington, D.C.

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DEDICATION

Those of us at NASA, who have worked incessantly since that day in January when the CHALLENGER and her crew, our friends, were lost, dedicate this report to those who will fly again into space in the future.

THE WHITE HOUSE

WASHINGTON

June 13, 1986

Dear Jim:

I have completed my review of the report from the Commission on the Space Shuttle CHALLENGER Accident. I believe that a program must be undertaken to implement its recommendations as soon as possible. The procedural and organizational changes suggested in the report will be essential to resuming effective and efficient Space Transportation System operations, and will be crucial in restoring U.S. space launch activities to full operational status.

Specifically, I would like NASA to report back to me in 30 days on how and when the Commission's recommendations will be implemented. This report should include milestones by which progress in the implementation process can be measured.

Let me emphasize, as I have so many times, that the men and women of NASA and the tasks they so ably perform are essential to the nation if we are to retain our leadership in the pursuit of technological and scientific progress.

Despite misfortunes and setbacks, we are determined to press on in our space programs. Again, Jim, we turn to you for leadership. You and the NASA team have our support and our blessings to do what has to be done to make our space program safe, reliable, and a source of pride to our nation and of benefit to all mankind.

I look forward to receiving your report on implementing the Commission's recommendations.

Sincerely,

Ronald Reagan

The Honorable James C. Fletcher
Administrator
National Aeronautics and
Space Administration
Washington, D.C. 20546

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

The President
The White House
Washington, DC 20500

Dear Mr. President:

I am pleased to submit the NASA plan to implement the recommendations of the Presidential Commission on the Space Shuttle Challenger Accident. The Commission has rendered the nation an exceptional service in conducting a comprehensive and thorough investigation. NASA agrees with the recommendations and is vigorously implementing them.

An overview of our efforts, the milestones by which we will measure our progress, and a detailed response to the specific Commission recommendations are provided in the enclosed report. A status report on our implementation program will be submitted in June 1987.

The men and women of NASA appreciate your continued personal support.

Respectfully,

James C. Fletcher
Administrator

Enclosure

Table of Contents

Executive Summary

On June 13, 1986, the President directed NASA to implement, as soon as possible, the recommendations of the Presidential Commission on the Space Shuttle Challenger Accident. The President requested that NASA report, within 30 days, how and when the recommendations will be implemented, including milestones by which progress can be measured.

In the months since the Challenger accident, the NASA team has spent many hours in support of the Presidential Commission on the Space Shuttle Challenger Accident and in planning for a return of the Shuttle to safe flight status. Chairman William P. Rogers and the other members of the Commission have rendered the Nation and NASA an exceptional service. The work of the Commission was extremely thorough and comprehensive. NASA agrees with the Commission's recommendations and is vigorously pursuing the actions required to implement and comply with them.

As a result of the efforts in support of the Commission, many of the actions required to safely return the Space Shuttle to flight status have been under way since March. On March 24, 1986, the Associate Administrator for Space Flight outlined a comprehensive strategy, and defined major actions, for safely returning to flight status. The March 24 memorandum (Appendix A) provided guidance on the following subjects:

- actions required prior to next flight,
- first flight/first year operations, and
- development of sustainable safe flight rate.

The Commission report was submitted to the President on June 9, 1986. Since that time, NASA has taken additional actions and provided direction required to comply with the Commission's recommendations (Appendix B). A summary of the key milestones is included at the end of the Executive Summary.

The NASA Administrator and the Associate Administrator for Space Flight will participate in the key management decisions required for implementing the Commission recommendations and for returning the Space Shuttle to flight status. NASA will report to the President on the status of the implementation program in June 1987.

The Commission report included nine recommendations, and a summary of the implementation status for each is provided:

Recommendation I

Solid Rocket Motor Design: On March 24, 1986, the Marshall Space Flight Center (MSFC) was directed to form a Solid Rocket Motor (SRM) joint redesign team to include participation from MSFC and other NASA centers as well as individuals from outside NASA. The team includes personnel from Johnson Space Center, Kennedy Space Center, Langley Research Center, industry, and the Astronaut Office. To assist the redesign team, an expert advisory panel was appointed which includes 12 people with six coming from outside NASA.

The team has evaluated several design alternatives, and analysis and testing are in progress to determine the preferred approaches which minimize hardware redesign. To ensure adequate program contingency in this effort, the redesign team will also develop, at least through concept definition, a totally new design which does not utilize existing hardware. The design verification and certification program will be emphasized and will include tests which duplicate the actual launch loads as closely as feasible and provide for tests over the full range of operating conditions. The verification effort includes a trade study which has been under way for several weeks to determine the preferred test orientation (vertical or horizontal) of the full-scale motor firings. The Solid Rocket Motor redesign and certification schedule is under review to fully understand and plan for the implementation of the design solutions as they are finalized and assessed. The schedule will be reassessed after the SRM Preliminary Design Review in September 1986. At this time it appears that the first launch will not occur prior to the first quarter of 1988.

Independent Oversight: In accordance with the Commission's recommendation, the National Research Council (NRC) has established an Independent Oversight Group chaired by Dr. H. Guyford Stever and reporting to the NASA Administrator. The NRC Oversight Group has been briefed on Shuttle system requirements, implementation, and control; Solid Rocket Motor background; and candidate modifications. The group has established a near-term plan that includes briefings and visits to review inflight loads; assembly processing; redesign status; and other solid rocket motor designs, including the Titan. Longer term plans are being formulated by the group including participation in the Solid Rocket Motor preliminary design review in September 1986.

Recommendation II

Shuttle Management Structure: The Administrator has appointed General Sam Phillips, who served as Apollo Program Director, to study every aspect of how NASA manages its programs, including relationships between various field centers and NASA Headquarters. General Phillips has broad authority from the Administrator to explore every aspect of NASA organization, management and procedures. His activities will include a review of the Space Shuttle management structure.

On June 25, 1986, Astronaut Robert Crippen was directed to form a fact-finding group to assess the Space Shuttle management structure. The group will report recommendations to the Associate Administrator for Space Flight by August 15, 1986. Specifically, this group will address the roles and responsibilities of the Space Shuttle Program Manager to assure that the position has the authority commensurate with its responsibilities. In addition, roles and responsibilities at all levels of program management will be reviewed to specify the relationship between the program organization and the field center organizations. The results of this study will be reviewed with General Phillips and the Administrator with a decision on implementation of the recommendations by October 1, 1986.

Astronauts in Management: Rear Admiral Richard Truly, a former astronaut, has been appointed as Associate Administrator for the Office of Space Flight. Several active astronauts are currently serving in management positions in the agency. The Crippen group will address means to stimulate the transition of astronauts into other management positions. It will also determine the appropriate position for the Flight Crew Operations Directorate within the NASA organizational structure.

Shuttle Safety Panel: A Shuttle Safety Panel will be established by the Associate Administrator for Space Flight not later than September 1, 1986, with direct access to the Space Shuttle Program Manager. This date allows time to determine the structure and function of this panel, including an assessment of its relationship to the newly formed Office of Safety, Reliability, and Quality Assurance, and to the existing Aerospace Safety Advisory Panel.

Recommendation III

Critical Item Review and Hazard Analysis: On March 13, 1986, NASA initiated a complete review of all Space Shuttle program failure modes and effects analyses (FMEA's) and associated critical item lists (CIL's). Each Space Shuttle project element and associated prime contractor is conducting separate comprehensive reviews which will culminate in a program-wide review with the Space Shuttle Program Manager at Johnson Space Center later this year. Technical specialists from outside the Space Shuttle program have been assigned as formal members of each of these review teams. All Criticality 1 and 1R critical item waivers have been cancelled. The teams are required to reassess and resubmit waivers in categories recommended for continued program applicability. Items which cannot be revalidated will be redesigned, qualified, and certified for flight. All Criticality 2 and 3 CIL's are being reviewed for reacceptance and proper categorization. This activity will culminate in a comprehensive final review with NASA Headquarters beginning in March 1987.

As recommended by the Commission, the National Research Council has agreed to form an Independent Audit Panel, reporting to the NASA Administrator, to verify the adequacy of this effort.

Recommendation IV

Safety Organization: The NASA Administrator announced the appointment of Mr. George A. Rodney to the position of Associate Administrator for Safety, Reliability, and Quality Assurance on July 8, 1986. The responsibilities of this office will include the oversight of safety, reliability, and quality assurance functions related to all NASA activities and programs and the implementation of a system for anomaly documentation and resolution to include a trend analysis program. One of the first activities to be undertaken by the new Associate Administrator will be an assessment of the resources including workforce required to ensure adequate execution of the safety organization functions. In addition, the new Associate Administrator will assure appropriate interfaces between the functions of the new safety organization and the Shuttle Safety Panel which will be established in response to the Commission Recommendation II.

Recommendation V

Improved Communications: On June 25, 1986, Astronaut Robert Crippen was directed to form a team to develop plans and recommended policies for the following:

- Implementation of effective management communications at all levels.
- Standardization of the imposition and removal of STS launch constraints and other operational constraints.
- Conduct of Flight Readiness Review and Mission Management Team meetings, including requirements for documentation and flight crew participation.

Since this recommendation is closely linked with the recommendation on Shuttle management structure, the study team will incorporate the plan for improved communications with that for management restructure.

This review of effective communications will consider the activities and information flow at NASA Headquarters and the field centers which support the Shuttle program. The study team will present findings and recommendations to the Associate Administrator for Space Flight by August 15, 1986.

Recommendation VI

Landing Safety: A Landing Safety Team has been established to review and implement the Commission's findings and recommendations on landing safety. All Shuttle hardware and systems are undergoing design reviews to insure compliance with the specifications and safety concerns. The tires, brakes, and nose wheel steering system are included in this activity, and funding for a new carbon brakes system has been approved. Runway surface tests and landing aid requirement reviews had been under way for some time prior to the accident and are continuing. Landing aid implementattion will be complete by July 1987. The interim brake system will be delivered by August 1987. Improved methods of local weather forecasting and weather-related support are being developed. Until the Shuttle program has demonstrated satisfactory safety margins through high fidelity testing and during actual landings at Edwards Air Force Base, the Kennedy Space Center landing site will not be used for nominal end-of-mission landings. Dual Orbiter ferry capability has been an issue for some time and will be thoroughly considered during the upcoming months.

Recommendation VII

Launch Abort and Crew Escape: On April 7, 1986, NASA initiated a Shuttle Crew Egress and Escape review. The scope of this analysis includes egress and escape capabilities from launch through landing and will provide analyses, concepts, feasibility assessments, cost, and schedules for pad abort, bailout, ejection systems, water landings, and powered flight separation. This review will specifically assess options for crew escape during controlled gliding flight and options for extending the intact abort flight envelope to include failure of 2 or 3 main engines during the early ascent phase. In conjunction with this activity, a Launch Abort Reassessment Team was established to review all launch and launch abort rules to ensure that launch commit criteria, flight rules, range safety systems and procedures, landing aids, runway configurations and lengths, performance versus abort exposure, abort and end-of-mission landing weights, runway surfaces, and other landing-related capabilities provide the proper margin of safety to the vehicle and crew. Crew escape and launch abort studies will be complete on October 1, 1986, with an implementation decision in December 1986.

Recommendation VIII

Flight Rate: In March 1986 NASA established a Flight Rate Capability Working Group. Two flight rate capability studies are under way: (1) a study of capabilities and constraints which govern the Shuttle processing flows at the Kennedy Space Center and (2) a study by the Johnson Space Center to assess the impact of flight specific crew training and software delivery/certification on flight rates. The working group will present flight rate recommendations to the Office of Space Flight by August 15, 1986. Other collateral studies are still in progress which address Presidential Commission recommendations related to spares provisioning, maintenance, and structural inspection. This effort will also consider the National Research Council independent review of flight rate which is under way as a result of a Congressional Subcommittee request.

NASA strongly supports a mixed fleet to satisfy launch requirements and actions to revitalize the United States expendable launch vehicle capabilities.

Additionally, a new cargo manifest policy is being formulated by NASA Headquarters which will establish manifest ground rules and impose constraints to late changes. Manifest control policy recommendations will be completed in November 1986.

Recommendation IX

Maintenance Safeguards: A Maintenance Safeguards Team has been established to develop a comprehensive plan for defining and implementing actions to comply with the Commission recommendations concerning maintenance activities. A Maintenance Plan is being prepared to ensure that uniform maintenance requirements are imposed on all elements of the Space Shuttle program. This plan will define the structure that will be used to document (1) hardware inspections and schedules, (2) planned maintenance activities, (3) maintenance procedures configuration control, and (4) maintenance logistics. The plan will also define organizational responsibilities, reporting, and control requirements for Space Shuttle maintenance activities. The maintenance plan will be completed by September 30, 1986.

A number of other activities are underway which will contribute to a return to safe flight and strengthening the NASA organization. A Space Shuttle Design Requirements Review Team headed by the Space Shuttle Systems Integration Office at Johnson Space Center has been assigned to review all Shuttle design requirements and associated technical verification. The team will focus on each Shuttle project element and on total Space Shuttle system design requirements. This activity will culminate in a Space Shuttle Incremental Design Certification Review approximately 3 months prior to the next Space Shuttle launch.

In consideration of the number, complexity, and interrelationships between the many activities leading to the next flight, the Space Shuttle Program Manager at Johnson Space Center has initiated a series of formal Program Management Reviews for the Space Shuttle program. These reviews are structured to be regular face-to-face discussions involving the managers of all major

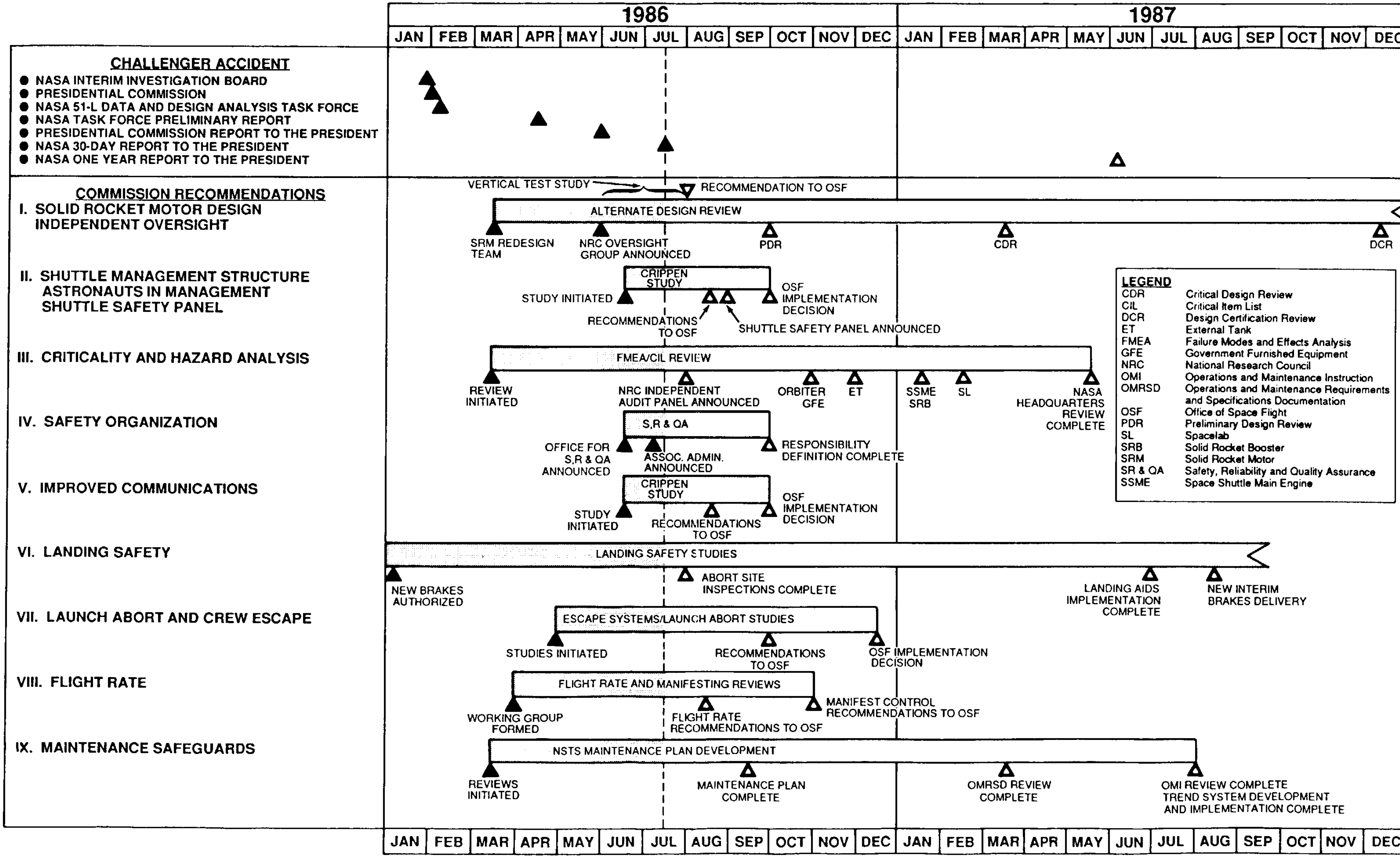
Space Shuttle program activities. Specific subjects to be discussed at each meeting will focus on progress, schedules, and actions associated with each of the major program review activities and will be tailored directly to current program activity for the time period involved. The first of these meetings was held at Marshall Space Flight Center on May 5-6, 1986, with the second at Kennedy Space Center on June 25, 1986. Follow-on reviews will be held approximately every 6 weeks. Results of these reviews will be reported to the Associate Administrator for Space Flight and to the NASA Administrator.

On June 19, 1986, the NASA Administrator announced termination of the development of the Centaur upper stage for use aboard the Space Shuttle. Use of the Centaur upper stage was planned for NASA planetary spacecraft launches as well as for certain national security satellite launches. Major safety reviews of the Centaur system were under way at the time of the Challenger accident, and these reviews were intensified in recent months to determine if the program should be continued. The final decision to terminate the Centaur stage for use with the Shuttle was made on the basis that even following certain modifications identified by the ongoing reviews, the resultant stage would not meet safety criteria being applied to other cargo or elements of the Space Shuttle system. NASA has initiated efforts to examine other launch vehicle alternatives for the major NASA planetary and scientific payloads which were scheduled to utilize the Centaur upper stage. NASA is providing assistance to the Department of Defense as it examines alternatives for those national security missions which had planned to use the Shuttle/Centaur.

The NASA Administrator has announced a number of Space Station organizational and management structural actions designed to strengthen technical and management capabilities in preparation for moving into the development phase of the Space Station program. The decision to create the new structure is the result of recommendations made to the Administrator by a committee, headed by General Phillips, which is conducting a long range assessment of NASA's overall capabilities and requirements.

Finally, NASA is developing plans for increased staffing in critical areas and is working closely with the Office of Personnel Management to develop a NASA specific proposal which would provide for needed changes to the NASA personnel management system to strengthen our ability to attract, retain, and motivate the quality work force required to conduct the NASA mission (Appendix C).

SPACE SHUTTLE RETURN TO FLIGHT



NASA Detailed Implementation of Presidential Commission Recommendations I - IX

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— I —

Design. The faulty Solid Rocket Motor joint and seal must be changed. This could be a new design eliminating the joint or a redesign of the current joint and seal. No design options should be prematurely precluded because of schedule, cost or reliance on existing hardware. All Solid Rocket Motor joints should satisfy the following requirements:

- The joints should be fully understood, tested and verified.
- The integrity of the structure and of the seals of all joints should be not less than that of the case walls throughout the design envelope.
- The integrity of the joints should be insensitive to:
  - Dimensional tolerances.
  - Transportation and handling.
  - Assembly procedures.
  - Inspection and test procedures.
  - Environmental effects.
  - Internal case operating pressure.
  - Recovery and reuse effects.
  - Flight and water impact loads.
- The certification of the new design should include:
  - Tests which duplicate the actual launch configuration as closely as possible.
  - Tests over the full range of operating conditions, including temperature.
- Full consideration should be given to conducting static firings of the exact flight configuration in a vertical attitude.

Independent Oversight. The Administrator of NASA should request the National Research Council to form an independent Solid Rocket Motor design oversight committee to implement the Commission's design recommendations and oversee the design effort. This committee should:

- Review and evaluate certification requirements.
- Provide technical oversight of the design, test program and certification.
- Report to the Administrator of NASA on the adequacy of the design and make appropriate recommendations.

NASA has formed a Solid Rocket Motor (SRM) Joint Redesign team at the Marshall Space Flight Center. This team includes personnel from several NASA Centers, industry, and the Astronaut Office. Their activities are being reviewed by a NASA/industry advisory panel and an Independent Oversight Group from the National Research Council.

The team has evaluated several design alternatives, and analysis and testing is in progress to determine the preferred approaches which minimize hardware redesign. In addition, an approach will be developed, at least through concept definition, for a new design which does not utilize existing hardware. The primary selection criteria will be development of an SRM joint design that is safe to fly. A secondary objective is to minimize schedule impact by use of existing hardware, if that can be done without compromising safety.

Analysis and testing is being performed to support the design selection process and to ensure the adequacy of the verification and certification of the redesigned joint. The static test orientation and configuration is being analyzed, and a proposed method is scheduled to be selected in July 1986. The Solid Rocket Motor redesign and certification schedule is under review to fully understand and plan for the implementation of the design solutions as they are finalized and assessed.

NASA Implementation of Recommendation I

On March 24, 1986, the Marshall Space Flight Center was directed to form a Solid Rocket Motor Redesign Team to include participation from Marshall, other NASA Centers, and the Astronaut Office, as well as individuals from outside NASA. To assist the redesign team, an expert advisory panel was appointed which includes 12 people, with six coming from outside NASA. The redesign team was directed to review the Commission findings and recommendations and develop a plan to provide a Solid Rocket Motor that addresses all the criteria in the Commission recommendations. The primary objective of the redesign effort is to provide a Solid Rocket Motor with field and nozzle joints that is safe to fly. A secondary objective will be to minimize the schedule impact by using existing hardware, if this can be done without compromising safety. To ensure adequate program contingency in this effort, the redesign group will also develop, at least through concept definition, a totally new design that does not utilize existing hardware. Key program milestones have been established. Emphasis is being placed on the verification effort to ensure its adequacy. As one part of the verification plan, a trade study is being conducted between vertical (nozzle up and down) and horizontal static tests to determine the preferred test firing orientation.

At the request of the NASA Administrator. the National Research Council (NRC) has established an Independent Oversight Group chaired by Dr. H. Guyford Stever and reporting directly to the Administrator. The NRC Oversight Group has been briefed on Shuttle system requirements, implementation, and control; Solid Rocket Motor background; and candidate modifications. The group has established a near-term plan that includes briefings and visits to review in-flight loads, assembly processing, redesign status, and other solid rocket motor designs, including the Titan. Longer term plans of the group are being formulated.

Many design alternatives have been evaluated, analyses and tests have been conducted, initial verification plans have been established, and overall schedules have been developed. In parallel, major SRM subassemblies and many critical processes have been reassessed, and efforts to determine those requiring additional review or modifications are in varying stages of maturity.

The team has evaluated several design alternatives and is conducting analyses and testing to determine the best approach which will utilize either existing hardware or modification of that in the production flow. An alternate joint design that does not utilize existing hardware is also under way. Additional design and studies are considering modifications to ground support equipment to resolve transportation, handling, and assembly difficulties encountered in the past, as well as ground and flight systems to compensate for the environmental effects of temperature and inclement weather. Other design modifications to reduce criticality or to resolve prior difficulties relating to the ignition system, factory joints, and nozzle are being considered. Design solutions for these modifications have been identified, and programmatic assessments are being finalized.

Analyses and tests have been performed to support design selection. The analyses relate to structural strength, dimensional tolerances, gas and thermal dynamics, elastomeric material behavior, and leak check adequacy. Tests being conducted range from small scale cold gas O-ring performance tests, to 70 pound motor hot gas insulation evaluation, to full size joint mating tests evaluating assembly aids. Further, thoroughly comprehensive analyses are under way and planned that will be test-verified to fully understand the joint operation. The total verification program comprises analyses and an extensive test program using subscale fixtures, full-size mated segments subjected to hot gas transient motor pressure, full-size segment assembly demonstrations, and four full scale static hot firing tests that will be either horizontal, vertical, or a combination of both. The static test orientation is being fully explored, and the preferred configuration is anticipated to be proposed in late July 1986. Two of these full-scale tests will contain all system changes.

The Solid Rocket Motor design schedule is currently under review to fully understand and plan for the implementation of the design solutions as they are finalized and assessed. The schedule will be reassessed after the Preliminary Design Review in September 1986.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— II —

Shuttle Management Structure. The Shuttle Program Structure should be reviewed. The project managers for the various elements of the Shuttle program felt more accountable to their center management than to the Shuttle program organization. Shuttle element funding, work package definition, and vital program information frequently bypass the National STS (Shuttle) Program Manager.

A redefinition of the Program Manager's responsibility is essential. This redefinition should give the Program Manager the requisite authority for all ongoing STS operations. Program funding and all Shuttle Program work at the centers should be placed clearly under the Program Manager's authority.

Astronauts in Management. The Commission observes that there appears to be a departure from the philosophy of the 1960s and 1970s relating to the use of astronauts in management positions. These individuals brought to their positions flight experience and a keen appreciation of operations and flight safety.

- NASA should encourage the transition of qualified astronauts into agency management positions.
- The function of the Flight Crew Operations director should be elevated in the NASA organization structure.

Shuttle Safety Panel. NASA should establish an STS Safety Advisory Panel reporting to the STS Program Manager. The charter of this panel should include Shuttle operational issues, launch commit criteria, flight rules, flight readiness and risk management. The panel should include representation from the safety organization, mission operations, and the astronaut office.

NASA is reviewing all aspects of its management structure. The Administrator requested General Sam Phillips to return to NASA and review all aspects of the organizational management structure and procedural activities. This activity is currently in process and is expected to continue for several months.

Astronaut Robert Crippen is leading a study addressing the STS management structure and the roles of astronauts in that structure. Specifically, the primary objective of the study is to strengthen the programmatic authority of STS management, and to clearly define the roles and responsibilities between the STS program and the NASA field centers. In addition, ways of encouraging astronauts to assume management positions will be identified as well as assessing their respective positions in the overall organizational structure. The results of this study will be thoroughly reviewed with General Phillips prior to incorporating the recommendations.

A Shuttle Safety Panel with direct access to the Associate Administrator for Space Flight as well as the NSTS Program Manager will be established by September 1, 1986. The exact structure of this group and its relationship with other NASA safety organizations is currently under study.

NASA Implementation of Recommendation II

NASA Administrator

NASA Administrator Dr. James C. Fletcher has appointed General Sam Phillips, who served as Apollo Program Director, to study every aspect of how NASA manages its programs, including relationships between the various centers and NASA Headquarters. General Phillips' review is not limited to the Challenger accident and operates with broad authority from the Administrator to examine all aspects of NASA's organization, management, and procedural activities. He will provide his findings and recommendations to the Administrator by the end of 1986.

Associate Administrator for Space Flight

On June 25, 1986, Astronaut Robert Crippen was directed to form a fact-finding group to assess the National Space Transportation System (NSTS) management structure including the Shuttle Program Manager's responsibilities, use of astronauts in management positions, and the functional location of the Flight Crew Operations Director in the organizational structure.

The fact-finding group consists of:

Robert Crippen, Group Leader
Richard Kohrs, Deputy Manager, NSTS Office
Walter Williams, Special Assistant to the NASA Administrator
George Page, LSOC, Director of STS Test Operations, Vandenberg Launch Site

This group is supplemented by individuals representing each of the field center institutions reporting to the Office of Space Flight:

Andrew Pickett, Kennedy Space Center
William Sneed, Marshall Space Flight Center
Clifford Charlesworth, Johnson Space Center
Roy Estess, National Space Technology Laboratories

The group is interviewing individuals at various management levels representing the STS program, the field center institutions, NASA Headquarters, and the major Shuttle contractors. In addition, the group will interview former senior program officials to gain their perspective from past program experience. Finally, the group will review the findings and proposals with a private consulting firm that is recognized as knowledgeable in management techniques.

As of this time, the group has completed interviews at the Marshall and Kennedy Space Flight Centers, with subsequent interview trips scheduled to the Johnson Space Center and various contractor locations. Presentations of findings and recommendations from this study will be presented to the Associate Administrator for Space Flight by August 15, 1986. The findings and recommendations will then be reviewed with the Administrator to insure that they are consistent with the overall recommendations being developed by General Phillips. The Office of Space Flight will then implement the recommendations as appropriate.

Specifically, the Level I/II/III program management concept will be reevaluated with changes implemented to strengthen the structure and to reduce the potential for conflict between the program organization and the NASA institutional organizations. In accordance with the Commission recommendations, strong consideration will be given to placing all Shuttle program funding and work at the centers under the Program Manager's authority.

In addition, means to implement the recommended use of astronauts in management positions will be identified. There are astronauts or former astronauts in ten management positions in the agency at this time, including the Associate Administrator for Space Flight. This brings the number of astronauts who have been included in management positions during the Shuttle program to approximately thirty, of which half have been in positions outside the Flight Crew Operations Directorate. This process is expected to continue and to be strengthened as the program management is restructured after this review.

The Associate Administrator for Space Flight will form a Shuttle Safety Panel by September 1, 1986. This panel will have direct access to the Associate Administrator for Space Flight and to the NSTS Program Manager. A detailed study to define the roles and responsibilities and the staffing of this panel is currently under way. In particular, the relationship to the newly formed Office of Safety, Reliability, and Quality Assurance, as well as the independent Aerospace Safety Advisory Panel, must be assessed.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— III —

Criticality Review and Hazard Analysis. NASA and the primary Shuttle contractors should review all Criticality 1, 1R, 2, and 2R items and hazard analyses. This review should identify those items that must be improved prior to flight to ensure mission success and flight safety. An Audit Panel, appointed by the National Research Council, should verify the adequacy of the effort and report directly to the Administrator of NASA.

NASA has initiated a review of all Space Shuttle Program Failure Modes and Effects Analyses, Critical Item Lists, and Hazard Analyses. Each Space Shuttle project element and its prime contractors are conducting independent reviews which will be integrated and assessed by the element project office. The results of these reviews and recommended actions will be provided to the NSTS Program Manager and to the Associate Administrator for Space Flight for final resolution. Technical specialists from outside the Space Shuttle program are assigned as formal members of each review team. The teams are reassessing all Criticality 1, 1R, 2, 2R, and 3 items. All Criticality 1 and 1R critical item waivers have been cancelled and must be resubmitted for approval after these reviews. The National Research Council has agreed to establish an Audit Panel to verify the adequacy of this effort and to report to the NASA Administrator on its findings.

NASA Implementation of Recommendation III

All STS project offices and element contractors are required to review their hardware design to identify those systems or components which if they fail could present a risk to the safety of the crew or could result in loss of the vehicle or mission. This is accomplished through a process defined in NASA Handbook 5300.4 and which requires the project to perform a Failure Modes and Effects Analysis (FMEA) and to develop a Critical Item List (CIL) and Hazard Analysis (HA) for each element. The purpose of the FMEA is to identify the various potential failure modes of the flight element components and assess the effects on the specific flight element as well as the total launch vehicle and mission. The potential failure modes are derived from analyses of function, design, and related manufacturing processes. The CIL identifies the critical failure modes and the rationale for retention. The items contained in the CIL are classified in five major categories commensurate with the degree of criticality. The five classifications of the CIL are as follows:

- 1 — Loss of life or vehicle
- 1R — Failure of both redundant hardware elements could cause loss of life or vehicle
- 2 — Loss of mission
- 2R — Failure of both redundant hardware elements could cause loss of mission
- 3 — All others

The Hazard Analysis identifies the hazards and their status of resolution and categorizes them as controlled (by design, procedure, etc.) or as an accepted risk. This review process was conducted during the development phase of the STS program prior to the first flight and FMEA's, CIL's, and HA's existed at the time of the 51-L launch.

The Commission recommended that a reassessment of the FMEA/CIL, in conjunction with the hazard analyses, be conducted to assure that Criticality 1, 1R, 2, and 2R items are reevaluated and that the hazard analyses properly identify the Criticality 1 items. Thus, the associated risks and hazards will be thoroughly understood and appropriate action can be taken to minimize their criticality. NASA accepts this recommendation and the review is under way.

The review was initiated by a March 13, 1986, letter from the NSTS Program Manager to all project elements requesting that each office review its CIL's and FMEA's. The purpose of the review is to affirm the completeness and accuracy of each FMEA/CIL for the current NSTS design. The March 24, 1986, memorandum from the Associate Administrator for Space Flight defining the strategy for safely returning the Space Shuttle to flight status, directed that Criticality 1 and 1R items be subjected to a total review with a complete reapproval process implemented and that those items which were not revalidated must be redesigned, certified, and qualified for flight. The memorandum also directed that all Criticality 2 and 3 CIL's be reviewed for reacceptance and proper categorization. On March 28, 1986, the NSTS Manager signed Program Directive S40019 which directed that all Criticality 1, 1R, and payload safety waivers be reverified, signed, and resubmitted for approval.

Following this direction, teams for each NSTS element project office (Level III), including the Solid Rocket Booster (SRB), External Tank (ET), Space Shuttle Main Engine (SSME), Orbiter, Government Furnished Equipment (GFE), Spacelab (SL), Kennedy Space Center (KSC), and Vandenburg Launch Site (VLS), have been formed and are reviewing the FMEA's, CIL's, and HA's which apply to their element hardware to assure that:

a. The failure modes, causes, and related effects are identified and documented.
b. The criticality has been properly assigned.
c. The retention rationale for each critical item is complete and accurate.

The reviews are being conducted by technical teams at the appropriate NASA centers and the element prime contractors. The results of both reevaluations will be presented to a Level III Configuration Control Board (CCB) Preboard which will review all NASA and contractor items and select those which require submittal to the Level III CCB for approval. The preboard will also review and recommend enhancements such as design and process changes, instrumentation and software additions, and testing or checkout changes which could be implemented to eliminate critical failure modes, reduce criticality, or minimize the possibility of failure or the effect of the failure. The preboard will select those items which should be submitted to the Level III CCB for review. The preboard membership will consist of, at a mimimum, the following members:

a. NASA engineering management representative
b. Safety representative
c. Reliability representative
d. Astronaut Office representative
e. Outside representative (not affiliated with the NSTS).

In addition to these project level reviews, selected independent contractors will review the ET, Orbiter, SRB, and SSME FMEA/CIL's and provide their assessment to the project manager.

The Level III CCB will review the preboard data and submit those significant items, including proposed enhancements, to the Level II Program Requirements Change Board (PRCB) for consideration by the NSTS Program Manager.

The element interface functional analysis is being reevaluated by the Systems Integration contractor. After this systems integration review, the results will be coordinated with the ET, Orbiter, SRB, and SSME Project Offices, and the coordinated results submitted to the Level II Systems Integration Review Board. The results will then be presented to the Level II PRCB for approval.

The Level II PRCB, including membership from the Aerospace Safety Advisory Panel, will review the Level III CCB significant items, CIL changes, and enhancement recommendations. The Level II PRCB may audit the enhancements not selected by Level III. The Level II PRCB will review and recommend any CIL changes and enhancements to Level I NASA Headquarters for approval. A summary of disapproved CIL changes and enhancements will also be documented and provided to Level I.

To assist in this process, the NSTS Program Manager has instituted a Level II Overview Group to assure that prime contractor reviews are consistent and conform to the Level II FMEA/CIL reevaluation plan. The ET contractor, Martin Marietta Corporation (MMC) at Michoud, was visited on June 16-20, 1986, with satisfactory results. The Orbiter contractor, Rockwell International (RI) at Downey, CA, will be visited the week of July 14, 1986. Rocketdyne, Thiokol, United Space Boosters Inc. (USBI), and other prime contractors, will be visited in the following weeks.

The Level II results and recommendations will be reviewed by Level I. The Level I board will be chaired by the NASA Associate Administrator for Space Flight and consist of his designated representatives. Level I will approve all items on the revalidated Criticality 1 and 1R CIL lists.

The overall reevaluation is planned to occur incrementally and is scheduled to continue through mid-1987. Each project manager will forward the results of their integrated review through the management approval cycle as each subsystem is completed. Safety engineering will present the results of the hazard analysis reevaluation to the Level III CCB, the Senior Safety Review Board, the Level II PRCB for approval, and NASA Headquarters for review.

The Commission recommended that the National Research Council (NCR) appoint an Audit Panel to verify the adequacy of this effort and report directly to the Administrator of NASA. This request has been made by NASA and accepted by the NRC. The NRC is forming the panel and NASA will support them as required.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— IV —

Safety Organization. NASA should establish an Office of Safety, Reliability and Quality Assurance to be headed by an Associate Administrator, reporting directly to the NASA Administrator. It would have direct authority for safety, reliability, and quality assurance throughout the agency. The office should be assigned the work force to ensure adequate oversight of its functions and should be independent of other NASA functional and program responsibilities.

The responsibilities of this office should include:

- The safety, reliability and quality assurance functions as they relate to all NASA activities and programs.
- Direction of reporting and documentation of problems, problem resolution and trends associated with flight safety.

On July 8, 1986, NASA Administrator Dr. James C. Fletcher announced the appointment of Mr. George A. Rodney to the position of Associate Administrator for Safety, Reliability, and Quality Assurance. In this position Mr. Rodney will have overall responsibility for development and oversight of all Safety, Reliability, and Quality Assurance functions within NASA. In addition, he will assume the responsibility of implementing a system for anomaly documentation and resolution to include a trend analysis program.

NASA Implementation of Recommendation IV

A NASA Office of Safety, Reliability, and Quality Assurance (SR&QA) headed by an Associate Administrator and reporting directly to the NASA Administrator has been established. This position will be responsible for the oversight of safety, reliability, and quality assurance functions related to all NASA activities and programs. In addition, it will be responsible for the direction of reporting and documentation of problems, problem resolution, and trends associated with safety.

Specifically, this office will be responsible for:

a. Establishment and implementation of agency SR&QA policies, plans, and procedures.
b. Insuring that risks are minimized by engineering design and operating procedures.
c. Investigation of and reporting on all NASA mishaps, incidents, and accidents.
d. Implementing a trend analysis program that includes accurate reporting of anomalies, analysis and testing of problems, and implementation of corrective measures.
e. Ensuring that SR&QA issues are fully considered at all design, flight, and test readiness reviews.
f. Ensuring that all NASA SR&QA organizations are adequately staffed with qualified personnel.
g. Maintaining an effective dynamic safety program.
h. Providing an integrated focus for agencywide program assurance policies.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— V —

Improved Communications. The Commission found that Marshall Space Flight Center project managers, because of a tendency at Marshall to management isolation, failed to provide full and timely information bearing on the safety of flight 51-L to other vital elements of Shuttle program management.

- NASA should take energetic steps to eliminate this tendency at Marshall Space Flight Center, whether by changes of personnel, organization, indoctrination or all three.
- A policy should be developed which governs the imposition and removal of Shuttle launch constraints.
- Flight Readiness Reviews and Mission Management Team meetings should be recorded.
- The flight crew commander, or a designated representative, should attend the Flight Readiness Review, participate in acceptance of the vehicle for flight, and certify that the crew is properly prepared for flight.

NASA is reviewing this recommendation as part of the review of the program management structure (Presidential Commission Recommendation II). The results of this activity will be presented to the Associate Administrator for Space Flight by August 15, 1986.

NASA Implementation of Recommendation V

On June 25, 1986, Astronaut Robert Crippen was directed to form a team to develop plans and policies for the following:

1. Implementation of effective management communication at all levels.

2. Standardization of the imposition and removal of STS launch constraints and other operational constraints.

3. Conduct of Flight Readiness Review and Mission Management Team meetings, including requirements for documentation and flight crew participation.

Because this recommendation is closely linked with Recommendation II, the study team will incorporate its plan for improved communications with that for the Shuttle management review. An integrated presentation of recommendations will be given to the Associate Administrator for Space Flight by August 15, 1986.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— VI —

Landing Safety. NASA must take actions to improve landing safety.

- The tire, brake and nosewheel steering systems must be improved. These systems do not have sufficient safety margin, particularly at abort landing sites.
- The specific conditions under which planned landings at Kennedy would be acceptable should be determined. Criteria must be established for tires, brakes and nosewheel steering. Until the systems meet those criteria in high fidelity testing that is verified at Edwards, landing at Kennedy should not be planned.
- Committing to a specific landing site requires that landing area weather be forecast more than an hour in advance. During unpredictable weather periods at Kennedy, program officials should plan on Edwards landings. Increased landings at Edwards may necessitate a dual ferry capability.

NASA has established a Landing Safety Team to develop an implementation plan to comply with the Commission recommendation. Some improvements to the brakes and nosewheel steering systems had been made and other changes were under way prior to the accident. These planned improvements are being reassessed and additional changes are under consideration. Tire, brake, and runway surface tests are being conducted, and a plan to standardize landing aids and to install arresting barriers at all runways has been developed. An improved weather forecasting and reporting capability is being developed which will enhance the forecasting of weather in support of launch and landing decisions. Planned end of mission landings at the Kennedy Space Center will occur only after adequate safety margins have been demonstrated by test and by landings at Edwards Air Force Base.

NASA Implementation of Recommendation VI

The NSTS Program Manager established a Landing Safety Team to review the Commission findings and recommendations on landing safety and to develop an implementation plan to comply with the Commission recommendations. This effort will include:

a. Identification of improvements required in tire, brake, nosewheel steering, and other landing systems to assure safe operation;
b. Development of a plan to implement the required improvements and to certify the overall landing system;
c. Determination of landing criteria for all potential landing sites, nominal and contingency;
d. Documentation of landing weather criteria for each site, taking local and seasonal variability and unpredictability into account.

Until the program has demonstrated satisfactory safety margins through high fidelity testing and during actual landings at Edwards Air Force Base, the Kennedy landing site will not be used for nominal end-of-mission landings.

Two brake improvement programs, a tire improvement study, a runway surface study and other hardware-related studies are under way. Design activities to improve the redundancy of the nosewheel steering system have been initiated. A plan to provide standard landing aids and other facilities including arresting barriers at all runways is being developed. An improved weather reporting capability is being developed which will enhance the weather forecasting in support of launch and landing decisions.

The two brake improvement programs currently under way include: an interim energy capability improvement to be implemented by first flight and a longer term carbon brake development program. The interim modification includes addition of six hydraulic system orifices, an improved brake wear-in procedure, and a stiffer axle to correct the dynamic oscillation phenomenon seen on early flights. Also included are a pressure balance feature to evenly distribute the energy load between inboard and outboard brakes and a thicker stator which promises to improve energy absorption capability. The long-term carbon brake program is planned to increase energy absorption capability by 80-100%.

The objective of the tire improvement study and runway surface study is to determine how best to decrease the tire wear experienced during previous KSC landings and to improve crosswind landing capability. Additionally, tests are planned at Wright Patterson AFB to improve the ability to mathematically model tire side force characteristics in support of upcoming simulations.

A major upgrade of the nosewheel steering system was accomplished prior to the STS 61-A flight. The system to date has demonstrated improved handling qualities but it is still characterized by several single point failure modes. Two design activities are under way to improve redundancy: fail operational fail-safe avionics with the current single string hydraulic system and total fail-operational fail-safe nosewheel steering (including hydraulics). Either system will require substantial software changes and pilot in-the-loop simulations for verification prior to flight test. Other hardware related studies in progress include tire blowout protection, autobraking, tire pressure instrumentation, and anti-skid improvements.

A thorough review (including climatological statistics) of the available runways in Europe and Africa has been accomplished to assist in evaluating those runways which can improve Trans-Atlantic Abort Landing (TAL) safety margins. A site survey team will look at four Moroccan runways in July. The findings of this team will be used to finalize the selection of a site and implement recommended improvements.

In addition, a plan to provide standard landing aids and other facilities at all runways has been adopted. This plan includes the procurement of arresting barriers to provide safe stops in the event of brake failures or unforecast wet runway conditions. A minimum weather reporting capability is being developed which should ensure acceptable weather for abort and end of mission landings.

The flight rules which govern the use of all landing sites, for both nominal and contingency situations, are being reevaluated. Differences in flight rules between nominal end-of-mission and abort landings may be necessary because of facility deficiencies at some abort landing sites; however, safety will not be significantly affected. This landing safety review process is an ongoing activity which will be refined as planned capabilities are implemented.

Providing a dual Shuttle Carrier Aircraft (SCA) capability for the Orbiter has been a programmatic issue for some time. The plans for use of Edwards Air Force Base as the landing site until landing safety margins are improved, will increase the need for a dual ferry capability. This issue will be thoroughly considered during the upcoming months.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— VII —

Launch Abort and Crew Escape. The Shuttle program management considered first-stage abort options and crew escape options several times during the history of the program, but because of limited utility, technical infeasibility, or program cost and schedule, no systems were implemented. The Commission recommends that NASA:

- Make all efforts to provide a crew escape system for use during controlled gliding flight.
- Make every effort to increase the range of flight conditions under which an emergency runway landing can be successfully conducted in the event that two or three main engines fail early in ascent.

NASA has initiated a review of the STS Crew Egress/Escape and launch abort capability. The crew Egress/Escape analysis is considering concepts for the total mission profile which includes pad activities, launch through flight to orbit, and descent from orbit to landing. To analyze each aspect of the mission, design teams for ground egress, bail-out ejection systems, water landings, and powered flight separation have been established, as well as a systems engineering team to maintain study continuity and integrate the results of the proposed systems concepts. In conjunction with the systems engineering team, an envelope definition team is providing the appropriate trajectories to be used by each team. The trajectories are being overlaid with the physiological envelope limits of the crew; the combined trajectory and physiological envelope are being evaluated against the capabilities of the various system concepts. From the data and preliminary analysis, the concepts determined to be most feasible will get further study. The teams will consider modifications to existing STS hardware and concepts which may be included in future vehicle designs.

A launch abort assessment team has been established to review all aspects of the abort options available during the launch phase. This team is reviewing the abort mode software implementation, procedures, and navigation targeting as well as the groundrules and constraints that are used during the design of the ascent trajectory. This team is reviewing all aspects of the launch process to assure that when operations resume, they are as safe as possible and maximize the opportunity for achieving an emergency runway landing during launch phase aborts.

NASA Implementation of Recommendation VII

STS Crew Egress and Escape System. The NSTS Program Manager initiated a study effort in April of this year to consider all aspects of atmospheric crew escape from the time of crew ingress on the pad to post landing Orbiter egress. This study is being conducted by a team led by the Johnson Space Center Engineering Directorate with support from the Astronaut Office. Inputs have been solicited and received from escape experts from the Navy and the Air Force as well as the Langley Research Center and the Kennedy Space Center. The team is reviewing past studies as well as new and innovative concepts. A review of the design ground rules confirmed that the Shuttle was designed for intact (runway landing) abort for the case of loss of thrust in one main engine. These analysis requirements have been expanded to include two and three engine out cases. The number of crew that each concept could safely extract and the crew survival requirements will be identified. The Crew Escape study will be completed on October 1, 1986, with an implementation decision in December 1986.

The current escape mode for other than intact abort is ditching. This study is emphasizing creation of an alternative to ditching and to expanding the escape envelope. The study team will identify the maximum altitude of escape coverage for ascent, abort, and entry for each individual concept under consideration. Thermal protection, oxygen, and pressure suit requirements will be identified for the concepts covering the higher altitudes.

The study effort is divided into teams covering first stage powered ascent, ejection systems, bailout, ditching, and ground egress. Consistent envelopes and costing techniques are being used to insure uniform assessment. Each team has derived several concepts and assessed the advantages, disadvantages, cost, and vehicle changes associated with each.

The preliminary conclusions resulting from the study are as follows:

- No concept provides complete coverage of the flight envelope.
- Low-cost options provide less envelope coverage.
- More costly concepts severely impact performance capability due to additional weight.
- Ditching is unpredictable and life threatening and should be avoided, if possible.

The preliminary recommendations of the study team are as follows:

- Initiate a study of manual and powered extraction bailout. Design goals should be early implementation, minimum weight, and maximum crew size.
- Initiate a long-range study for combinations of ejection seats and passenger compartments.
- Continue ditching structural integrity studies and initiate crew simulation training for ditching.
- Initiate a detailed feasibility study of aeroseparation during first stage (prior to SRB separation) flight.
- Flame protection should be provided for the launch pad access area, the hazardous gas detection system should be reviewed, and TV coverage of the total crew egress route should be provided.
- Reanalyze the slide system from platform to basket to bunker to transport vehicle.
- Augment Orbiter post landing egress capability with a slide.
- Assign a pad egress safety manager with overall pad egress safety responsibility.

The preliminary recommendations are being reviewed at this time, and hardware contractors will be requested to provide study plans, design proposals, and funding requirements for review by the NSTS Program Office prior to any final implementation decision.

Launch/Abort Reassessment. A Launch/Abort Reassessment Team was formed to perform a total review of the launch phase and abort options available within that phase. This team will insure that all available options to provide emergency runway landing capability are defined. These options will then be reviewed by the NSTS Program Manager prior to any implementation decisions being made.

This team has been formed and is divided into subgroups. These sub-groups and their work are described in subsequent paragraphs. The initial thrust of this team has been directed toward those long-lead decisions required for the first flight; namely, an evaluation of the Trans-Atlantic Abort mode, participation in the flight design process, and a review of the required flight software changes. The flight design baseline is now complete, and a report citing the acceptability of the Trans-Atlantic Abort mode has been provided to the Program Manager.

The Abort Mode Implementation subgroup has focused on the first flight activities. This group is reviewing the final submittal of flight software modifications, the certification history of the ascent abort modes, the verification process for both onboard and ground software, contingency procedures, and abort targeting.

The Ascent Design subgroup is reviewing the ground rules and constraints that are used to shape the ascent trajectory, as well as the methods of predicting ascent performance margin. Flight product development processes and the verification of these products are also being reviewed. The techniques and procedures for assuring the ability of the vehicle to perform in the ascent environment, as it is observed to exist on launch day, will also be assessed.

The Systems Management subgroup is reviewing all vehicle systems and their operational management. Issues uncovered during these review sessions are being resolved by the group, where possible, and, when required, issues are fowarded to the appropriate level of management. Changes are being made to vehicle requirements, ground and flight documentation, flight rules, flight software, and where necessary, flight hardware changes are being proposed.

The Range Safety subgroup, which also includes Air Force personnel, will assure the adequacy of the tools, procedures, and rules for developing the proper blend of flight and ground safety during the ascent phase. The group is reviewing the Space Shuttle range safety hardware to evaluate the need for carrying destruct charges on both the External Tank and Solid Rocket Boosters.

Other subgroups of this team are reviewing weather statistics and forecasting tools and techniques as they pertain to launch and landing operations. The process of implementing flight software products to meet flight requirements is also being reviewed. The Launch Commit Criteria and Flight Rule review groups have begun a systematic review of the decision making criteria used to commit a vehicle to launch and to govern the decision making processes used in flight.

This Launch/Abort Reassessment Team will review every aspect of the launch process and assure that when operations resume, they are as safe as possible. The Launch/Abort study will be complete on October 1, 1986, with an implementation decision in December 1986.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— VIII —

Flight Rate. The nation's reliance on the Shuttle as its principal space launch capability created a relentless pressure on NASA to increase the flight rate. Such reliance on a single launch capability should be avoided in the future.

NASA must establish a flight rate that is consistent with its resources. A firm payload assignment policy should be established. The policy should include rigorous controls on cargo manifest changes to limit the pressures such changes exert on schedules and crew training.

NASA has formed a Flight Rate Capability Working Group to assess a safe, sustainable flight rate and to identify the constraints to this rate. The flight rate capability study will consider all required work for the standard vehicle processing flow and assure that the work is optimized in relation to the available workforce considering such factors as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, and work balancing across shifts. The flight production study will review the requirements for mission planning, flight production development, payload assignment policy and controls and achievable software delivery capability to support flight controllers and crew training. These studies will consider the availability of the third Orbiter Processing Facility, the availability of spares, as well as the effects of supporting the Vandenberg Launch Site to determine the maximum achievable safe flight rate.

A cargo manifest policy is being formulated by NASA Headquarters which will establish manifest groundrules and impose constraints to late changes.

NASA supports increased emphasis on a mixed fleet and action to revitalize the United States expendable launch vehicle capability.

NASA Implementation of Recommendation VIII

The assessment of a safe sustainable NSTS flight rate capability was initiated in March 1986 with the establishment of a formal Flight Rate Capability Working Group. This group includes representation from Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, NASA Headquarters, Vandenberg Launch Site and Air Force Space Division.

Under the direction of this working group, flight rate capability studies are under way at Kennedy Space Center and Johnson Space Center. These studies will assess the best estimate of flight rate capability and will identify potential constraints to that rate. An integral part of the flight rate planning mechanism will be the identification and implementation of program enhancements (facilities, manpower, support equipment, procedures, production improvements) required to achieve the flight rate. The flight rate assessment will also consider flight software development and design, crew training requirements, spares provisioning, as well as maintenance and structural inspection requirements. Flight rate analyses tools and procedures that will support both accurate flight rate projection and detailed operations schedules at the Kennedy Space Center are planned. The National Research Council is conducting an assessment of the flight rate capability at the request of the Chairman of the House Subcommittee on HUD-Independent Agencies. NASA is supporting this analysis and will incorporate the results into the assessment of flight rate.

NASA has participated in Senior Interagency Group discussions on overall United State space launch strategy. NASA supports increased emphasis on a mixed fleet and actions to revitalize the United States expendable launch vehicle capabilities.

A cargo manifest policy is being formulated by NASA Headquarters which will establish manifest ground rules and impose constraints to late changes. Cargo manifest change control is being pursued through the generation of a set of manifest stability groundrules and policies which will apply to both NASA Headquarters and the program level. Proposals are being formulated at the Johnson Space Center for submission to NASA Headquarters in November 1986. In addition, manifest change impact prediction and measurement tools are being developed. Integrated scheduling and resource prediction concepts have been defined and the necessary software programming initiated.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— IX —

Maintenance Safeguards. Installation, test, and maintenance procedures must be especially rigorous for Space Shuttle items designated Criticality 1. NASA should establish a system of analyzing and reporting performance trends of such items.

Maintenance procedures for such items should be specified in the Critical Items List, especially for those such as the liquid-fueled main engines, which require unstinting maintenance and overhaul.

With regard to the Orbiters, NASA should:

- Develop and execute a comprehensive maintenance inspection plan.
- Perform periodic structural inspections when scheduled and not permit them to be waived.
- Restore and support the maintenance and spare parts programs, and stop the practice of removing parts from one Orbiter to supply another.

NASA is developing an NSTS Maintenance Plan to ensure that uniform maintenance requirements are imposed by all program elements. This plan will define inspection requirements and frequency, periodic maintenance requirements and schedules, configuration control requirements and organizational responsibility, and reporting requirements. All existing test and checkout requirements documents are being reviewed and will consider the results of the ongoing Critical Items List (CIL) reviews to ensure consistency between the CIL requirements and Operations and Maintenance Instructions at the Kennedy Space Center and the Vandenburg Launch Site. NASA is actively reviewing its policy and future planning for program logistics including spare parts provisioning.

NASA Implementation of Recommendation IX

The NSTS has established a Maintenance Safeguards Team with representatives from the Johnson (JSC), Kennedy (KSC), and Marshall (MSFC) Space Flight Centers to develop a comprehensive plan for defining and implementing actions in compliance with Presidential Commission Recommendation IX. This team will serve as the focal point for all the NSTS maintenance activity and will ensure that an adequate maintenance program is in place and well understood by all elements of the program.

A National Space Transportation System Maintenance Plan is being prepared to ensure that uniform maintenance requirements are imposed by all elements of the NSTS Program. This plan will define the documentation and implementation requirements for (1) hardware inspections and schedules, (2) planned maintenance activities and schedules, (3) maintenance procedures configuration control, and (4) maintenance logistics. The plan will also define organizational responsibilities, reporting, and control requirements for NSTS maintenance activities.

Maintenance requirements for checkout, tests, inspections, servicing, and repair will be validated for both vehicle processing and depot level repair activities. The effort for the vehicle processing activity is defined and scheduled after completion of the Failure Modes and Effects Analysis/Critical Items List Review currently under way. Planning for a Depot Level Repair Requirements Review has been initiated. The Operations Maintenance Requirement Specification Document (OMRSD) which defines all test and checkout requirements is being reviewed to ensure that the requirements are complete and that the required testing is consistent with the results of the Critical Items List (CIL) review.

Maintenance procedures used by the launch sites and repair agencies are being validated by technical teams including membership from the design centers and element contractors to ensure proper implementation of requirements. Verification of Shuttle vehicle checkout and processing procedures is currently being accomplished in the Operations and Maintenance Instruction (OMI) review. An activity to establish methods to rigorously control baselined procedures for safety-related critical items and to obtain design center concurrence on any changes to these critical procedures is in place.

The problem reporting and corrective action systems presently being used by JSC, KSC, and MSFC are being consolidated and reviewed for uniformity in documentation, reporting, and trend analyses requirements based on failure and process nonconformance experience. Safety, reliability, and quality assurance activities will be an integral part of the NSTS Maintenance Program. These activities will be closely coordinated with the newly formed office of the Associate Administrator for Safety, Reliability, and Quality Assurance.

Maintenance Inspection Plans are being developed by each NSTS Project. The Space Shuttle Main Engine Project has a program approved inspection plan in place. This plan will be examined and its adequacy verified. The Orbiter Project has submitted, for program baselining, an inspection plan resulting from studies done by a major airline company. This plan establishes rigorous requirements, schedules, and a closed loop feedback mechanism for providing launch site inspection results to project personnel. Inspection plans for the External Tank and Solid Rocket Booster Projects are being developed.

The logistics program for the Orbiter vehicle has been a concern of the program since the completion of developmental flights. The lack of sufficient spare parts led to practices such as removal of parts from one Orbiter to supply another. NASA has initiated an assessment of spare parts requirements to adequately support the flight rate planning. Progress has been made with the construction of a large logistic facility at KSC in which all available parts can be stored. Additionally, the Orbiter Prime Contractor has established a Logistics Service Center near Kennedy Space Center which provides field maintenance capability for a number of Orbiter subsystem elements. Contractual and government management changes have been made which will improve the logistics planning. Measurement criteria for monitoring the availability of spare parts are being developed and given proper attention by program management. A rigorous, closed-loop, accounting system that provides the discipline to assure compliance with all program approved check-out, tests, inspections, servicing, and repair requirements is being established.

Appendix A

March 24, 1986 Memorandum from the Associate Administrator for Space Flight:

Strategy for Safely Returning the Space Shuttle to Flight Status

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of M

MAR 2 4 1986

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Strategy for Safely Returning the Space Shuttle to Flight Status

This memorandum defines the comprehensive strategy and major actions that, when completed, will allow resumption of the NSTS flight schedule. NASA Headquarters (particularly the Office of Space Flight), the OSF centers, the National Space Transportation System (NSTS) program organization and its various contractors will use this guidance to proceed with the realistic, practical actions necessary to return to the NSTS flight schedule with emphasis on flight safety. This guidance is intended to direct planning for the first year of flight while putting into motion those activities required to establish a realistic and an achievable launch rate that will be safely sustainable. We intend to move as quickly as practicable to complete these actions and return to safe and effective operation of the National Space Transportation System.

Guidance for the following subjects is included:

- o ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT
- o FIRST FLIGHT/FIRST YEAR OPERATIONS
- o DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT:

Reassess Entire Program Management Structure and Operation

The NSTS program management philosophy, structure, reporting channels and decision-making process will be thoroughly reviewed and those changes implemented which are required to assure confidence and safety in the overall program, including the commit to launch process. Additionally, the Level I/II/III budget and management relationships will be reviewed to insure that they do not adversely affect the NSTS decision process.

Solid Rocket Motor (SRM) Joint Redesign

A dedicated SRM joint design group will be established at MSFC, with selective participation from other NASA centers and external organizations, to recommend a program plan to quantify the SRM joints problem and to accomplish the SRM joints redesign. The design must be reviewed in detail by the program to include PDR, CDR, DCR, independent analysis, DM-QM testing, and any other factors necessary to assure that the overall SRM is safe to commit to launch. The type and content of post-flight inspections for the redesigned joints and other flight components will be developed in detail, with criteria developed for commitment to the next launch as well as reusability of the specific flight hardware components.

Design Requirements Reverification

A review of the NSTS Design Requirements (Vol. 07700) will be conducted to insure that all systems design requirements are properly defined. This review will be followed by a delta DCR for all program elements to assure the individual projects are in compliance with the requirements.

Complete CIL/OMI Review

All Category 1 and 1R critical items will be subjected to a total review with a complete reapproval process implemented. Those items which are not revalidated by this review must be redesigned, certified, and qualified for flight. The review process will include a review of the OMI's, OMRSD's, and other supporting documentation which is pertinent to the test, checkout, or assembly process of the Category 1 and 1R flight hardware. KSC will continue to be responsible for all OMI's with design center concurrence required for those which affect Category 1 and 1R items. Category 2 and 3 CIL's will be reviewed for reacceptance and to verify their proper categorization.

Complete OMRSD Review

The OMRSD will be reviewed to insure that the requirements defined in it are complete and that the required testing is consistent with the results of the CIL review. Inspection/retest requirements will be modified as necessary to assure flight safety.

Launch/Abort Reassessment

The launch and launch abort rules and philosophy will be assessed to assure that the launch and flight rules, range safety systems/operational procedures, landing aids, runway configuration and length, performance vs. TAL exposure, abort weights, runway surface, and other landing related capabilities provide an acceptable margin of safety to the vehicle and crew. Additionally, the weather forecasting capability will be reviewed and improved where possible to allow for the most accurate reporting.

FIRST FLIGHT/FIRST YEAR OPERATIONS

First Flight

The subject of first flight mission design will require extensive review to assure that we are proceeding in an orderly, conservative, safe manner. To permit the process to begin, the following specific planning guidance applies to the first planned mission:

- daylight KSC launch
- conservative flight design to minimize TAL exposure
- repeat payload (not a new payload class)
- no waiver on landing weight
- conservative launch/launch abort/landing weather
- NASA-only flight crew
- engine thrust within the experience base
- no active ascent/entry DTO's
- conservative mission rules
- early, stable flight plan with supporting flight software and training load
- daylight EDW landing (lakebed or runway 22)

First Year

The planning for the flight schedule for the first year of operation will reflect a launch rate consistent with this conservative approach. The specific number of flights to be planned for the first year will be developed as soon as possible and will consider KSC and VAFB work flow, software development, controller/crew training, etc. Changes to flight plans, ascent trajectories, manifest, etc., will be minimized in the interest of program stability. Decisions on each launch will be made after thorough review of the previous mission's SRM joint performance, all other specified critical systems performance and resolution of anomalies.

In general, the first year of operation will be maintained within the current flight experience base, and any expansion of the base, including new classes of payloads, will be approved only after very thorough safety review. Specifically, 109 percent thrust levels will not be flown until satisfactory completion of the MPT testing currently being planned, and the first use of the Filament Wound Case will not occur with the first use of 109 percent SSME thrust level. Every effort will be made to conduct the first VAFB flight on an expeditious and safe schedule which supports national security requirements.

DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

The ultimate safe, sustainable flight rate, and the buildup to that rate, will be developed utilizing a "bottoms-up" approach in which all required work for the standard flow as defined in the OMRSD is identified and that work is optimized in relation to the available work force. Factors such as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, work balancing across shifts, etc., will be considered, as well as timely mission planning, flight product development and achievable software delivery capability to support flight controllers and crew training. This development will consider the availability of the third orbiter facility, the availability of spares, as well as the effects of supporting VAFB launch site operations.

THE BOTTOM LINE

The Associate Adminstrator for Space Flight will take the action for reassessment of the NSTS program management structure. The NSTS Program Manager at Johnson Space Center is directed to initiate and coordinate all other actions required to implement this strategy for return to safe Shuttle flight.

I know that the business of space flight can never be made to be totally risk-free, but this conservative return to operations will continue our strong NASA/Industry team effort to recover from the Challenger accident. Many of these items have already been initiated at some level in our organizations, and I am fully aware of the tremendous amount of dedicated work which must be accomplished. I do know that our nation's future in space is dependent on the individuals who must carry this strategy out safely and successfully. Please give this the widest possible distribution to your people. It is they who must understand it, and they who must do it.

Richard H. Truly

Appendix B

NASA memoranda directing the implementation of the Presidential Commission on the Space Shuttle Accident Recommendations

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JUN 20 1986

TO: M/Associate Administrator for Space Flight

FROM: A/Administrator

SUBJECT: Presidential Commission Recommendations Action Plan

The President has reviewed the report from the Commission on the Space Shuttle CHALLENGER accident and on June 13 directed NASA to undertake a program to implement its recommendations as soon as possible. The President directed me to report to him in 30 days on how and when the Commission's recommendations will be implemented. This report should include milestones by which progress in the implementations process can be measured.

The Office of the Administrator assumes responsibility for recommendation number 4 on safety organization. I have previously announced NASA's establishment of the Office of Safety, Reliability, and Quality Assurance to answer this recommendation. The Office of Space Flight is directed to take the action for all other Commission recommendations and to prepare the NASA report to the President.

I plan to report to the President on July 11, 1986. Please status me on your progress on a weekly basis.

Jim F

James C. Fletcher

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TELEGRAPHIC MESSAGE

NAME OF AGENCY	PRECEDENCE	SECURITY CLASSIFICATION
NASA HEADQUARTERS	ACTION: ROUTINE INFO:	UNCLASSIFIED
ACCOUNTING CLASSIFICATION MAA	DATE PREPARED 6/13/86	FILE
FOR INFORMATION CALL		
NAME RICHARD H. TRULY	PHONE NUMBER 453-1132	TYPE OF MESSAGE ☐ SINGLE ☐ BOOK ☒ MULTIPLE-ADDRESS

THIS SPACE FOR USE OF COMMUNICATION UNIT

MESSAGE TO BE TRANSMITTED *(Use double spacing and all capital letters)*

TO:
JOHNSON SPACE CENTER

HOUSTON, TX

ATTN: GA/MR. A. ALDRICH

ATTN: AA/MR. J. MOORE

KENNEDY SPACE CENTER

KENNEDY SPACE CENTER, FL

ATTN: CD/MR. R. SMITH

MARSHALL SPACE FLIGHT CENTER

MARSHALL SPACE FLIGHT CENTER, AL

ATTN: DA01/DR. LUCAS

NATIONAL SPACE TECHNOLOGY LABORATORIES

NSTL STATION, MS

ATTN: AA00/MR. I. HLASS

SUBJECT: PRESIDENTIAL COMMISSION RECOMMENDATIONS

PAGE NO.	NO. OF PGS.	SECURITY CLASSIFICATION
1	3	UNCLASSIFIED

STANDARD FORM 14
REVISED 11-80
GSA FPMR (41 CFR) 101-35.306
Previous editions usable NSN 7540-00-634-3988
14-109
★ U.S. GOVERNMENT PRINTING OFFICE : 1983 O - 381-526 (8273)

TELEGRAPHIC MESSAGE

NAME OF AGENCY	PRECEDENCE	SECURITY CLASSIFICATION
NASA HEADQUARTERS	ACTION: ROUTINE INFO:	UNCLASSIFIED
ACCOUNTING CLASSIFICATION MAA	DATE PREPARED 6/13/86	FILE

FOR INFORMATION CALL

NAME	PHONE NUMBER	TYPE OF MESSAGE
RICHARD H. TRULY	453-1132	☐ SINGLE ☐ BOOK ☒ MULTIPLE-ADDRESS

THIS SPACE FOR USE OF COMMUNICATION UNIT

MESSAGE TO BE TRANSMITTED *(Use double spacing and all capital letters)*

TO:

IN A MEETING TODAY BETWEEN THE PRESIDENT AND THE NASA ADMINISTRATOR, PRESIDENT REAGAN DIRECTED THAT A PROGRAM BE UNDERTAKEN TO IMPLEMENT THE PRESIDENTIAL COMMISSION RECOMMENDATIONS AS SOON AS POSSIBLE.

THE PROCEDURAL AND ORGANIZATIONAL CHANGES SUGGESTED IN THE REPORT WILL BE ESSENTIAL TO RESUMING EFFECTIVE AND EFFICIENT SPACE TRANSPORTATION SYSTEM OPERATIONS, AND WILL BE CRUCIAL IN RESTORING U.S. SPACE LAUNCH ACTIVITIES TO FULL OPERATIONAL STATUS.

NASA WILL REPORT BACK TO THE PRESIDENT IN 30 DAYS ON HOW AND WHEN THE COMMISSION RECOMMENDATIONS WILL BE IMPLEMENTED INCLUDING MILESTONES BY WHICH PROGRESS CAN BE MEASURED.

SPECIFIC DIRECTION REGARDING THOSE ACTIONS REQUIRED TO IMPLEMENT EACH COMMISSION RECOMMENDATION WILL BE FORTHCOMING WITHIN THE NEXT SEVERAL DAYS. RECOMMENDATION 4 (SAFETY ORGANIZATION) WILL BE ADDRESSED BY THE ADMINISTRATOR. RECOMMENDATION 2 (SHUTTLE MANAGEMENT STRUCTURE,

PAGE NO.	NO. OF PGS.	SECURITY CLASSIFICATION
2	3	UNCLASSIFIED

STANDARD FORM 14
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TELEGRAPHIC MESSAGE

NAME OF AGENCY	PRECEDENCE	SECURITY CLASSIFICATION
NASA HEADQUARTERS	ACTION: ROUTINE INFO:	UNCLASSIFIED
ACCOUNTING CLASSIFICATION: MAA	DATE PREPARED: 6/13/86	FILE
FOR INFORMATION CALL		
NAME: RICHARD H. TRULY	PHONE NUMBER: 453-1132	TYPE OF MESSAGE: ☐ SINGLE ☐ BOOK ☒ MULTIPLE-ADDRESS

THIS SPACE FOR USE OF COMMUNICATION UNIT

MESSAGE TO BE TRANSMITTED *(Use double spacing and all capital letters)*

TO:

ASTRONAUTS IN MANAGEMENT, SHUTTLE SAFETY PANEL) AND RECOMMENDATION 5 (IMPROVED COMMUNICATIONS) WILL BE ADDRESSED BY LEVEL I. ALL OTHER RECOMMENDATIONS WILL BE WORKED THROUGH LEVEL II, NSTS PROGRAM MANAGER.

THE STS 51-L TASK FORCE ACTION CENTER IS HEREBY REDESIGNATED THE NSTS ACTION CENTER. I INTEND THAT THE NSTS ACTION CENTER SHALL BE USED TO COORDINATE AND TRACK THE PROGRESS OF EACH OF OUR ACTIONS AND TO BE THE NSTS POINT OF CONTACT FOR ORGANIZATIONS EXTERNAL TO THE NSTS RELATING TO THE COMMISSION REPORT.

AS PRESIDENT REAGAN STATED TODAY IN HIS LETTER TO DR. FLETCHER, "...THE MEN AND WOMEN OF NASA AND THE TASKS THEY SO ABLY PERFORM ARE ESSENTIAL TO THE NATION IF WE ARE TO RETAIN OUR LEADERSHIP IN THE PURSUIT OF TECHNOLOGICAL AND SCIENTIFIC PROGRESS." DR. FLETCHER AND I HAVE COMPLETE CONFIDENCE IN OUR ABILITY TO ORGANIZE OUR RESPONSE TO THE ROGERS COMMISSION REPORT AND TO CONTINUE OUR EFFORTS TO RETURN TO A SAFE FLIGHT STATUS.

Richard H. Truly

RICHARD H. TRULY
ASSOCIATE ADMINISTRATOR
FOR SPACE FLIGHT

PAGE NO.	NO. OF PGS.	SECURITY CLASSIFICATION
3	3	UNCLASSIFIED

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

TO: Johnson Space Center
Attn: GA/Manager, NSTS Office

FROM: M/Associate Administrator for Space Flight

SUBJECT: Implementation of Presidential Commission Recommendations

This direction amplifies my TWX of June 13, 1986, same subject. You are hereby assigned responsibility for the action associated with the Presidential Commission Recommendations I, III, VI, VII, VIII, and IX. In fulfilling these actions, you will be responsible directly to the Associate Administrator for Space Flight.

Specific actions required for each recommendation are enclosed. You should develop a reporting plan that provides me regular visibility into the status of all actions. Action status will be routed through the NSTS Action Center. My point of contact is Mr. J. Honeycutt, FTS 453-1261.

In order to support the Administrator's initial report to the President, your first status is required not later than July 3, 1986. Mr. D. Branscome, FTS 453-1125, is my point of contact to develop this report. Please work directly with him to reach an agreement on format and content of the portion which concerns your actions.

This work is of the utmost importance to return the U.S. safely to manned space flight. Its importance cannot be overstressed to those who accomplish the work associated with these actions.

Richard H. Truly

Enclosure

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

TO: M/Robert L. Crippen

FROM: M/Associate Administrator for Space Flight

SUBJECT: Implementation of Presidential Commission Recommendations

This direction amplifies my TWX of June 13, 1986, same subject. You are hereby assigned responsibility for the action associated with the Presidential Commission Recommendations II and V. In fulfilling these actions, you will be responsible directly to the Associate Administrator for Space Flight.

Specific actions required for each recommendation are enclosed. You should develop a reporting plan that provides me regular visibility into the status of all actions. Action status will be routed through the NSTS Action Center. My point of contact is Mr. J. Honeycutt, FTS 453-1261.

In order to support the Administrator's initial report to the President, your first status is required not later than July 3, 1986. Mr. D. Branscome, FTS 453-1125, is my point of contact to develop this report. Please work directly with him to reach an agreement on format and content of the portion which conerns your actions.

This work is of the utmost importance to return the U.S. safely to manned space flight. Its importance cannot be overstressed to those who accomplish the work associated with these actions.

Richard H. Truly

Enclosure

Appendix C

NASA letter to the Office of Personnel Management on revitalization of NASA through concepts contained in the President's proposed Civil Service Simplification Act

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JUL 10 1986

Honorable Constance Horner
Director, Office of Personnel
Management
1900 E Street, NW
Washington, DC 20415

Dear Mrs. Horner:

We appreciate the offer you made in the June 13, 1986, meeting with Dr. Fletcher and myself to help in revitalizing NASA. The timing could not be better for us to explore jointly innovative ways to manage NASA personnel matters.

Since our initial meeting, we have taken steps to work with your office to develop an approach to implement the concepts contained in the President's proposed Civil Service Simplification Act, with the support of both the Administration and the Congress. Gaining the flexibility to better challenge and reward our personnel would greatly help NASA's effort to move forward.

We plan to work with your staff to refine these efforts and keep the project moving on a very fast track.

Your continued efforts in partnership with NASA will be vital to our success.

Sincerely,

William R. Graham

William R. Graham
Deputy Administrator

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